Technology Development and Diffusion
in
New Brunswick Manufacturing

The Final Report of the Technology Diffusion Project
to the Department of Economic Development and Tourism
The Province of New Brunswick

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1 Introduction: The Technology Diffusion Project

The Technology Diffusion Project was a study into technology diffusion in New Brunswick manufacturing conducted at Mount Allison University by a research team under the supervision of Dr. Brian Campbell and Dr. Roger Wehrell. The surveys and fieldwork associated with the project were carried out in the spring and summer of 1990. The research was directed toward several questions associated with technology diffusion. As expressed in the research proposal for the project, its objectives were:

1. To identify the factors that drive the successful adoption of technology by the New Brunswick workforce.
2. To identify the factors that drive New Brunswick owners/managers to seek new technology.
3. To identify where New Brunswick owners/managers are presently turning to find new technology and how these firms conduct their search.
4. To identify how New Brunswick firms manage their technology after it is acquired, including how they adopt, adapt and safeguard proprietary technology.
5. To identify any significant difference between New Brunswick firms and other Canadian firms with respect to items 1 to 4.
6. Based on the research for 1 through 5 to suggest ways and means of improving the transfer of technology from provincial technology centres and other sources to New Brunswick industry (this is not a study of the provincial technology centres).

This is the Final Report of the Technology Diffusion Project. The first section of this report is an introduction and an outline of the research project. The second section explains the orientation of New Brunswick manufacturing firms to technology. Questions 1, 2, 4, and 5 are considered in this section. Section 3 deals with question 3 by concentrating on the patterns of diffusion. Section 4 analyzes the workforce adoption of new technology expressed in question

1. Finally, section 5 examines the ways and means of improving technology transfer directed by question 6.

1.1 Product and Process Technologies

While the general subject of this report is technology management and technological innovation in the manufacturing sector, its specific focus is product technology and manufacturing process technology. The focus is on Process Technology, the way that the firm manufactures or processes what it sells, and on Product Technology, the way its products work or are designed.

1.2 Methodology: Surveys and Detailed Field Studies

The research design involved two main components, a survey of a broad cross-section of New Brunswick manufacturing firms, and the more detailed study of the situation of ten firms.

1.2.1 The Survey

The survey population of 107 firms was selected from a data base of all manufacturing firms in New Brunswick maintained by the Department of Commerce and Technology of the Province of New Brunswick. There was a response rate of 71.2%. There were three components to the survey; a CEO interview, a process technology questionnaire, and a product technology questionnaire.

1.2.1.1 The CEO Interview

We interviewed the CEO of the firm. This interview established some of the general characteristics of the firm and addressed some of the specific aspects of the firm associated with the development and exploitation of technology. The CEO interview schedule is reproduced in Appendix 1 on page 113. The interviews were conducted in English or French, depending on the preference of the respondent.

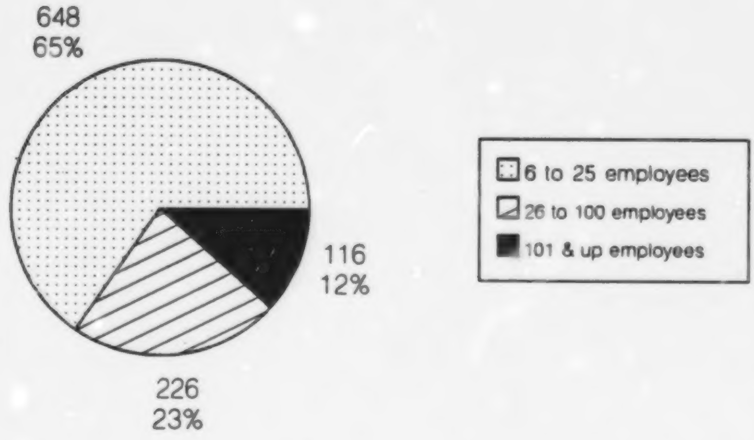
1.2.1.2 The Process and Product Questionnaires

Product and process technologies were studied through the use of questionnaires. In the CEO interview, senior management in each firm was asked to identify a recent product change and a recent process change within the firm. One questionnaire for each change and the technology involved was left with the firm by the interviewer and returned by mail. Each questionnaire was filled out by a person directly associated with the product or process change. We received 42 completed process questionnaires (or 54% of those who participated) and 40 completed product questionnaires (or 51% of those firms who participated). An additional 8 firms stated that there had not been any changes in their firm in the last 5 years and did not fill out the questionnaires. The questionnaires were specifically directed toward the analysis of change and as a result the survey deals with a cross-section of the most dynamic New Brunswick manufacturing firms in our sample. The Product and Process questionnaires are reproduced in Appendix 2 on page 143. They were provided in English and French versions depending on the preference of the respondent.

1.2.1.3 Survey Sampling by Size of Firm

The population sampled for this survey was all New Brunswick manufacturing and processing firms with more than 5 employees as their maximum workforce during 1989. The majority of these firms are small with a maximum employment of 6 to 25 employees. Only 12% had more than 100 employees in 1989.

Figure 1 New Brunswick Manufacturing Firms by Employees



The sampling procedure weighted firms with respect to numbers of employees to yield equal numbers of firms in each of three size categories;

Small	6 to 25 employees
Medium	26 to 100 employees
Large	over 100 employees.

Throughout the analysis we have used size as determined by employee numbers and refer to firms as small, medium, and large.

It is important to note that firms, with 100 employees or less, are often considered small in business studies. Our approach has two strengths. On the one hand, it distinguishes small and very small firms. This allows us to be sensitive to small business concerns. On the other hand, we have sampled so as to weight these divisions more equally. In this way we have a better selection of large businesses than we would get from a blind random sample since large firms by this definition comprise a small fraction of the New Brunswick manufacturing firms. Using these procedures we arrived at a distribution of respondents across the three size classifications as follows:

Small	36.4%
Medium	35.1%
Large	28.6%

1.3 Methodology: The Detailed Field Studies

Ten firms were selected for Detailed Field Studies. These firms were not included in the survey. A more open ended approach was taken in the selection of Detailed Study firms. These firms tended to be more proactive in their management of technology than the typical firm but they were selected from a broad range of industries. Some of the industries were characterized by sophisticated developing technologies and others by mature relatively stable ones. The firms were studied in an exploratory way with repeated follow up visits. The experiences within these firms were used to flesh out the more standardized data from the survey.

2 Technology on the Margins

This section of the report covers several topics connected with the place of technology in New Brunswick manufacturing. In this section we discuss the types of technologies used by New Brunswick manufacturing firms; the distinction between product and process technologies; the extent to which changes in manufacturing are changes in technology; the degree of innovation of new technologies in New Brunswick manufacturing; the structure of new Brunswick Manufacturing firms; R&D investment; specialized R&D personnel; the forces which drive new technology; and the way firms manage new technologies. The general argument that we make is that technology is a marginal concern for the typical New Brunswick manufacturing firm. The dynamics and implications of this aspect of New Brunswick manufacturing are explored.

2.1 Innovations and Technologies

The survey looked at technology management practices in process and product innovation. One component of the study was a survey of particular innovations. Product and process innovations may or may not involve new technology. What is innovative about a particular product innovation may be some aspect of its marketing or promotion as opposed to how it performs or how it is manufactured. A process innovation may involve only the reorganization of the workforce and work routine in some way without changing the production technology. Respondents were asked first to identify an innovation, then to describe certain aspects of how that innovation was managed and only then to identify any new technologies or technologically innovative aspects of the innovation. For 2.3% of the process innovations, respondents failed to identify a technological innovation and for 10.3% of product innovations they stated that there was no new technology involved. Change in general is closely identified with technological change.

2.1.1 Process Technology Changes

Survey respondents indicated technological innovation was more common in certain areas of the manufacturing process than in others. The most commonly affected technology among the process innovations surveyed was the basic process technology. This category covered a multitude of technological innovations from new recipes to new assembly techniques. 63% of the innovations involved new technologies in this area. Other areas of production commonly affected were machine tool technology and machine control technology. 41.2% and 39% of the process innovations involved new technologies in these areas respectively. Overall results are summarized in Table 1. These composite tables condense the number of tables required for complex comparisons. Please refer to Appendix 3 on page 171 for details where table one is discussed as an example.

Table 1 New Technologies in Process Innovations

	FIRM SIZE			Total
	Small	Medium	Large	
New Technologies				
Process.............	10	7	9	26
....	38.5%	26.9%	34.6%	100.0%
....	76.9%	58.3%	64.3%	66.7%
Materials...........	4	3	3	10
....	40.0%	30.0%	30.0%	100.0%
....	30.8%	25.0%	21.4%	25.6%
Materials Handling..	3	3	6	12
....	25.0%	25.0%	50.0%	100.0%
....	23.1%	25.0%	42.9%	30.8%
Machine tool........	6	3	6	15
....	40.0%	20.0%	40.0%	100.0%
....	46.2%	25.0%	42.9%	38.5%
Machine control.....	6	3	8	17
....	35.3%	17.6%	47.1%	100.0%
....	46.2%	25.0%	57.1%	43.6%
Testing monitoring..	4	4	2	10
....	40.0%	40.0%	20.0%	100.0%
....	30.8%	33.3%	14.3%	25.6%
Info systems........	1	2	3	6
....	16.7%	33.3%	50.0%	100.0%
....	7.7%	16.7%	21.4%	15.4%
Packaging...........	0	3	4	7
....	.0%	42.9%	57.1%	100.0%
....	.0%	25.0%	28.6%	17.9%
Maintenance.........	4	4	4	12
....	33.3%	33.3%	33.3%	100.0%
....	30.8%	33.3%	28.6%	30.8%
Physical plant......	0	1	3	4
....	.0%	25.0%	75.0%	100.0%
....	.0%	8.3%	21.4%	10.3%
Total...............	13	12	14	39
....	100.0%	100.0%	100.0%	100.0%
....	33.0%	31.0%	36.0%	100.0%

2.1.2 Product Technology Changes

In the survey of product innovations we asked about the technologies associated with the change. Firms indicated that materials, components, and product design were all important about 50% of the time. The most common technology change associated with product innovations was how the product was manufactured. Many product innovations involved process technology innovations. Results are summarized in Table 2 below.

Table 2 New Technologies in Product Innovations

	FIRM SIZE			Total
	Small	Medium	Large	
New Technologies				
Materials	7	5	6	18
	38.9%	27.8%	33.3%	100.0%
	50.0%	50.0%	54.5%	51.4%
Components	6	5	4	15
	40.0%	33.3%	26.7%	100.0%
	42.9%	50.0%	36.4%	42.9%
Product design	8	4	5	17
	47.1%	23.5%	29.4%	100.0%
	57.1%	40.0%	45.5%	48.6%
Packaging	3	3	4	10
	30.0%	30.0%	40.0%	100.0%
	21.4%	30.0%	36.4%	28.6%
Distribution	3	3	3	9
	33.3%	33.3%	33.3%	100.0%
	21.4%	30.0%	27.3%	25.7%
Manufacturing	7	5	10	22
	31.8%	22.7%	45.5%	100.0%
	50.0%	50.0%	90.9%	62.9%
Post purchase service	1	1	1	3
	33.3%	33.3%	33.3%	100.0%
	7.1%	10.0%	9.1%	8.6%
No new technologies.	0	0	0	0
	.0%	.0%	.0%	.0%
	.0%	.0%	.0%	.0%
Total	14	10	11	35
	100.0%	100.0%	100.0%	100.0%
	40.0%	28.6%	31.4%	100.0%

2.1.3 Product and Process Technologies: Conclusions

The product process distinction is useful in that it can direct us to different aspects of the manufacturing enterprise. However, when technologies are considered, the most common product innovations involve process technology innovations. Technological innovation is closely associated with process innovation. Another striking thing about the way in which innovation is characterized is the extent to which it is identified with technology. Virtually all of the innovations are identified by firms as involving some form of technological change.

2.2 Degree of Innovation and Originality of Innovation

In considering the development of new technologies we were interested in the degree and extent of innovation. In doing this we looked at the degree to which technological changes in New Brunswick manufacturing firms represent departures from

(1) past practice within the firm and
(2) practices in other firms either inside the firm's industry and province or outside it.

For example, a particular process innovation could implement a technology unfamiliar to the firm surveyed but in common use elsewhere. The firm may have copied it or borrowed it or bought it from firms already employing it. A particular process innovation might also involve a technology unlike technologies employed by other firms in the industry. It could be a technology in some way original to the firm surveyed.

The surveys of particular process and product innovations included questions about the degree of innovation involved. A respondent's judgment comparing the innovation to prior products or processes in the firm may be taken as a good indication of how much the innovation differed from practices and technologies with which the firm was already familiar. The respondent's perceptions of the innovation's difference or similarity to what other firms had already been doing may be taken as less reliable concerning what was actually the case. Some respondents seemed to compare their innovation only with the practice of firms in a narrowly defined industry or geographical area, perhaps reflecting limitations on their knowledge of other firms. For example, a manufacturer of a specialized type of fishing boat judged his product innovation of a freezer unit on the boats he built to have been "an original product of an entirely new type." This may have been so with regard to the specific type of boat manufactured in a select area of New Brunswick, but clearly it was not so with regard to the fishing boat building industry as a whole. Another example, is a bakery which characterized its new low cholesterol product line as a totally different type of product as compared to other bakeries. The context here must be very local given the prevalence of these types of products in Canada. This tendency to exaggerate the degree of originality, particularly with respect to product innovations, means that the following results should be interpreted carefully.

Nevertheless, despite the exaggeration of innovation for some, the trend is for respondents to perceive the innovations surveyed as similar to what the firm was already familiar with and to what other firms were already doing -- particularly with regard to process innovations. As outlined in Table 3, 81% of the respondents view their process innovations as similar to, or the same as, processes and technologies already in place in other firms. Further, 41% of these firms indicated that these processes were different for their firm. Innovation in this case is coming up to the practices in other firms. Also, 57.1% view process changes as similar to practices and technologies already in place in the firm. Process technology changes in New Brunswick manufacturing tend to be incremental.

Product changes show a slightly different pattern. There was less of a tendency to perceive similarity between the firm's innovation and either its prior products or the products of other firms. In Table 4 the reader can see that almost half, 47.5%, perceived the product change as different from other products within the firm while 75% indicated that the product change was similar, an adaption, or the same as products in other firms.

Table 3 Perceptions of Innovativeness of Process Changes

Differences from processes in the firm	Differences from processes outside the firm: The same as used by other firms	Similar to processes used by other firms	Different from processes already used in other firms	Total
Modification of a process already used in the firm	9 75.0% 52.9%	1 8.3% 5.9%	2 16.7% 25.0%	12 100.0% 28.6%
New process, similar to processes already in use	4 33.3% 23.5%	6 50.0% 35.3%	2 16.7% 25.0%	12 100.0% 28.6%
New process, different from those already in use	4 22.2% 23.5%	10 55.6% 58.8%	4 22.2% 50.0%	18 100.0% 42.9%
Total	17 100.0% 40.5%	17 100.0% 40.5%	8 100.0% 19.0%	42 100.0% 100.0%

Table 4 Perceptions of Innovativeness of Product Changes

	Differences from products outside firm				Total
Differences from products in firm	Same as others	Adaption of others	Similar to others	Different from others	
Modification	4	3	0	2	9
	44.4%	33.3%	.0%	22.2%	100.0%
	28.6%	50.0%	.0%	20.0%	22.5%
Similar	5	1	5	1	12
	41.7%	8.3%	41.7%	8.3%	100.0%
	35.7%	16.7%	50.0%	10.0%	30.0%
Different	5	2	5	7	19
	26.3%	10.5%	26.3%	36.8%	100.0%
	35.7%	33.3%	50.0%	70.0%	47.5%
Total	14	6	10	10	40
	100.0%	100.0%	100.0%	100.0%	100.0%
	35.0%	15.0%	25.0%	25.0%	100.0%

These results suggest that most innovation in New Brunswick manufacturing involves the importation of established technologies to the firm. It is a form of getting the firm up to "best practice". It is also important to consider that the tables above represent responses from only 2/3 of the firms who participated in the questionnaire. These were the firms which positively indicated that there had been changes. For many firms in New Brunswick no change is the norm.

2.3 The Structure of Firms and the Commitment to Technology

This section of the report describes structural aspects of New Brunswick manufacturing firms. It outlines characteristics of the firms which are relevant to a consideration of technology diffusion and transfer. After this review we develop an overall picture of New Brunswick manufacturing.

2.3.1 Firm Size

The size of a firm is a good indicator of its organizational complexity and the degree of job specialization within its workforce. It is also an indicator of the resources a firm has to commit to technological development. As outlined above, the firms in this study were classified as small, medium, and large using maximum number of employees as the criterion for the size categories.

2.3.2 Industry Sector

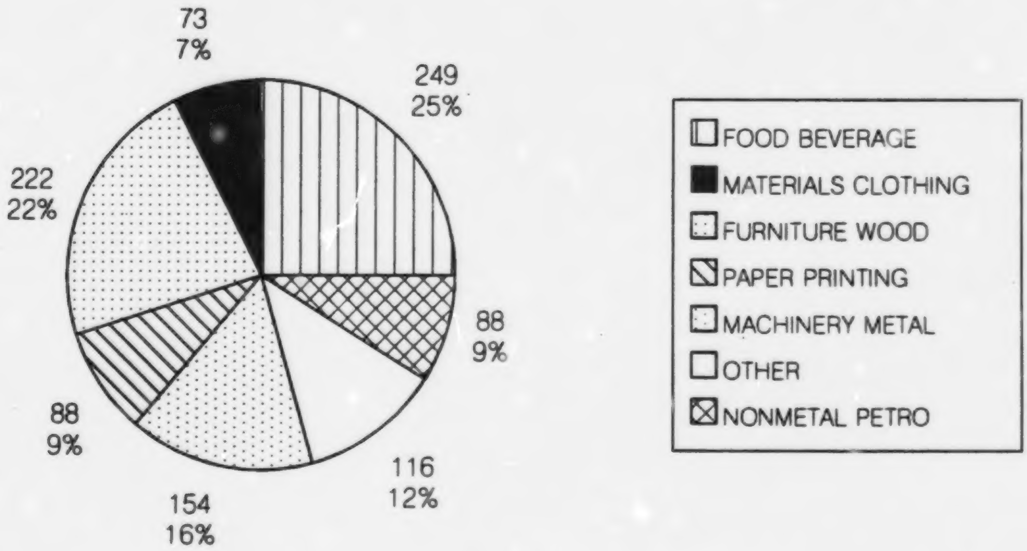
The industry or industries in which a firm competes is an important factor in understanding its ways of managing innovation and technology. In certain industries firms commit large amounts of resources to formally organized research and development efforts. Statistics Canada has designated such industries "high tech" on the basis of industry wide dollar expenditures on R&D. In other industries it is typical not to invest in the firm's own R&D activity but rather to buy new technology from suppliers of production equipment. In yet other industries, in the declining phase of their life cycle, it is the practice to avoid large scale technological innovation.

For the purposes of profiling the distribution of New Brunswick's manufacturing firms by industry and of drawing a representative sample, this study used the 22 major SIC codes in Statistics Canada's classification of manufacturing and processing firms. It combined the 22 divisions into 7 business sectors as outlined below.

Sector	Sic Codes
Food Beverage	10 Food
	11 Beverage
	12 Tobacco
Materials Clothing	15 Rubber
	16 Plastic
	17 Leather
	18 Primary Textile
	19 Textile Products
	24 Clothing
Furniture Wood	25 Wood
	26 Furniture Fixture
Paper Printing	27 Paper
	28 Printing
Machinery Metal	29 Primary Metal
	30 Fabricated Metal
	31 Machinery
Other	32 Transport Equipment
	33 Electrical
	39 Other
Nonmetal Petro	35 Nonmetal Mineral
	36 Petroleum Coal
	37 Chemical

The distribution of New Brunswick firms among these sectors overall is as follows.

Figure 2 New Brunswick Manufacturing by Sector



There are two important observations to make about this distribution. First it is extremely heavy in sectors with industries classified as "Low tech" and also as "mature industries". Consider the following industry ranking by technological status from the Economic Council of Canada report Making Technology Work (1987).

High-tech
- Motor vehicles
- Electrical and electronic products
- Rubber and plastics
- Transportation equipment
- Motor vehical parts and accessories
- Machinery
  - Mining, metallurgical and forestry machinery
  - Energy & environmental equipment and refining machinery
  - Service industries equipment
  - Aeorspace subsystems
  - Ocean industries equipment and machinery
- Chemicals
- Construction
  - Agricultural construction & material handling equipment

Mid-tech
- Miscellaneous manufacturing
  - Prefabricated structures
  - Secondary Industries-- Tools, Machinery & equipment
  - Leisure products & crafts
  - Cultural industries

- Textiles
- Paper
- Iron and steel

Low-tech

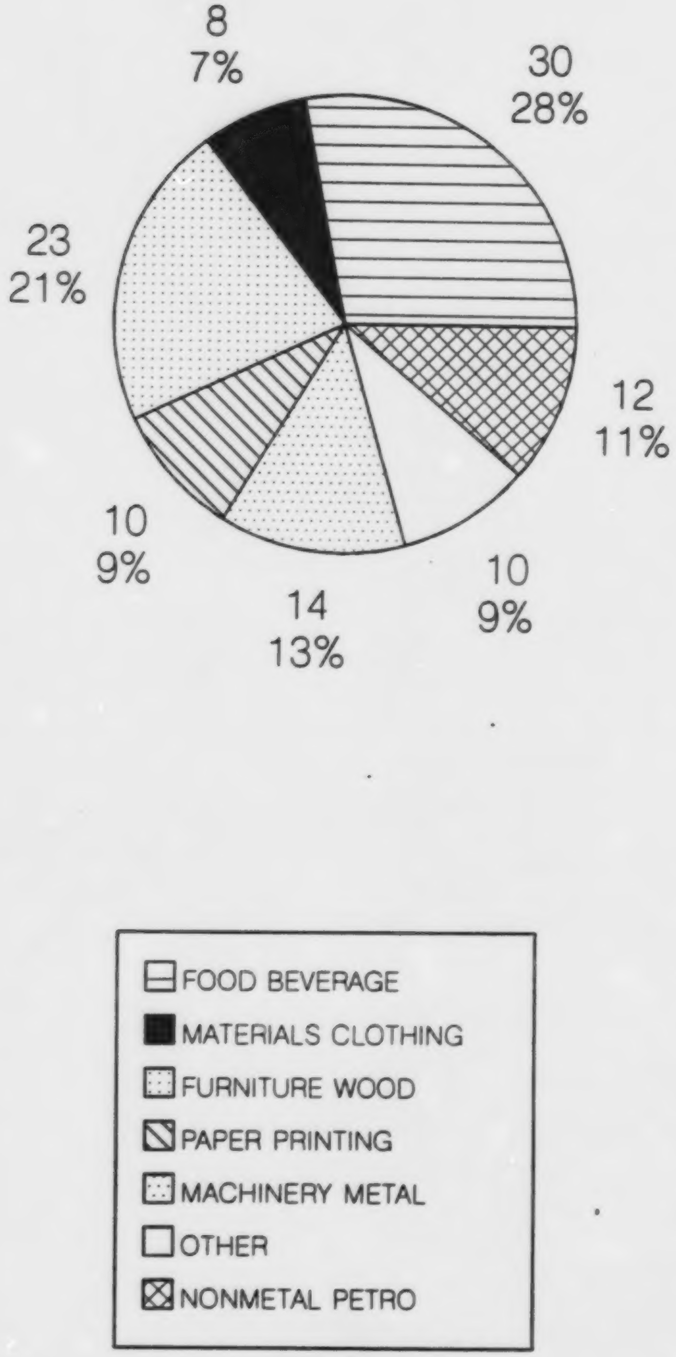
- Nonmetallic mineral products
- Printing and publishing
- Leather
- Furniture and fixtures
- Wood
  - Primary wood products
  - Manufactured wood products
- Fabricated metals
- Knitting and clothing
- Tobacco products
- Food and beverages
- Petroleum and coal products

Among the industries ranked as low-tech are those which make up the 'Food Beverage' and the 'Furniture Wood' sectors used in this our study. These sectors include New Brunswick's seafood processing and wood product industries respectively. These alone comprise 47% of the firms in New Brunswick manufacturing and processing.

Second, the sector our study designates as 'Other' includes not only what Statistics Canada designates "Other Manufacturing" but also what it designates "Transportation Equipment" and "Electrical and Electronic Products". These last two groups are large nationally but have only token representation in New Brunswick; therefore, they are grouped together in the 'Other' sector which still consists of only 12% of the total. This is a major portion of what the EEC designates "High tech" industry.

These two observations underscore the fact that the profile of New Brunswick firms with respect to technological sophistication differs from that of other parts of Canada and that it likely contains a greater proportion of technologically unsophisticated firms. The survey sample was intended to be representative of the population with respect to distribution across industrial sectors. The profile of the survey respondents is given below. It closely approximates that of the population.

Figure 3 Sample Firms by Sector



2.4 Technological Commitment

In the next few pages we outline various aspects of Technological Commitment. By this we mean the various ways in which a firm commits resources to the development of technology. Three aspects of technological commitment will be discussed: Expenditures, Specialization, and Professionalization.

2.4.1 Technological Commitment: Expenditure

One of the ways to examine the technological commitments of firms is to look at budgeting and expenditures on technology associated activities. The column charts in Figure 4 summarize indicators of spending on activities associated with technology development in the survey firms. When we look at formal budgeting practices in the first panel of Figure 4, it is clear that only 19% of all firms had any budget at all for R&D activity. Budgeting for R&D is more common the larger the firm, going from 11% to 19% to 32% for small, medium, and large firms respectively. This data gives the impression that new technologies are not important to New Brunswick manufacturing firms.

A different picture emerges from the contrast between the lack of formal budgeting for R&D and the other indicators of spending on technology associated activities. The remaining panels of Figure 4 look at spending in 1989. In the survey we asked firms whether they had made expenditures and how much they had spent in three areas of activity: R&D in general, product development and process improvement. Many of the expenditures on activities that were identified as falling into these areas came out of other operating budgets, such as equipment maintenance, or out of capital budgets, such as the installation of new equipment. When actual spending on technology development activities is considered, a different judgment emerges on the firms' commitment to technology development than would emerge from a consideration only of figures of formally budgeted R&D.

The most striking contrast is between those who foresee R&D activity and plan for it through the budgeting process and those who do not plan for it through the budgeting process but who, in hindsight, identify activity that involves some aspect of research and/or development. Panel 2 in Figure 4 shows that 53% of all firms identified spending on R&D.

It is clear that many firms spend on R&D whether they plan for it or not. It is also evident that smaller firms do not plan as much as large firms. Their budgeting processes are less well developed. Also there is every indication (from our more detailed field studies) that those firms with a budget line for R&D often spent more than they had planned. This 'Ad Hoc' spending pattern shows the reactive nature of New Brunswick manufacturing. In the main New Brunswick firms react to circumstances to keep up. Spending on technology is a practical contingent business not a driving force.

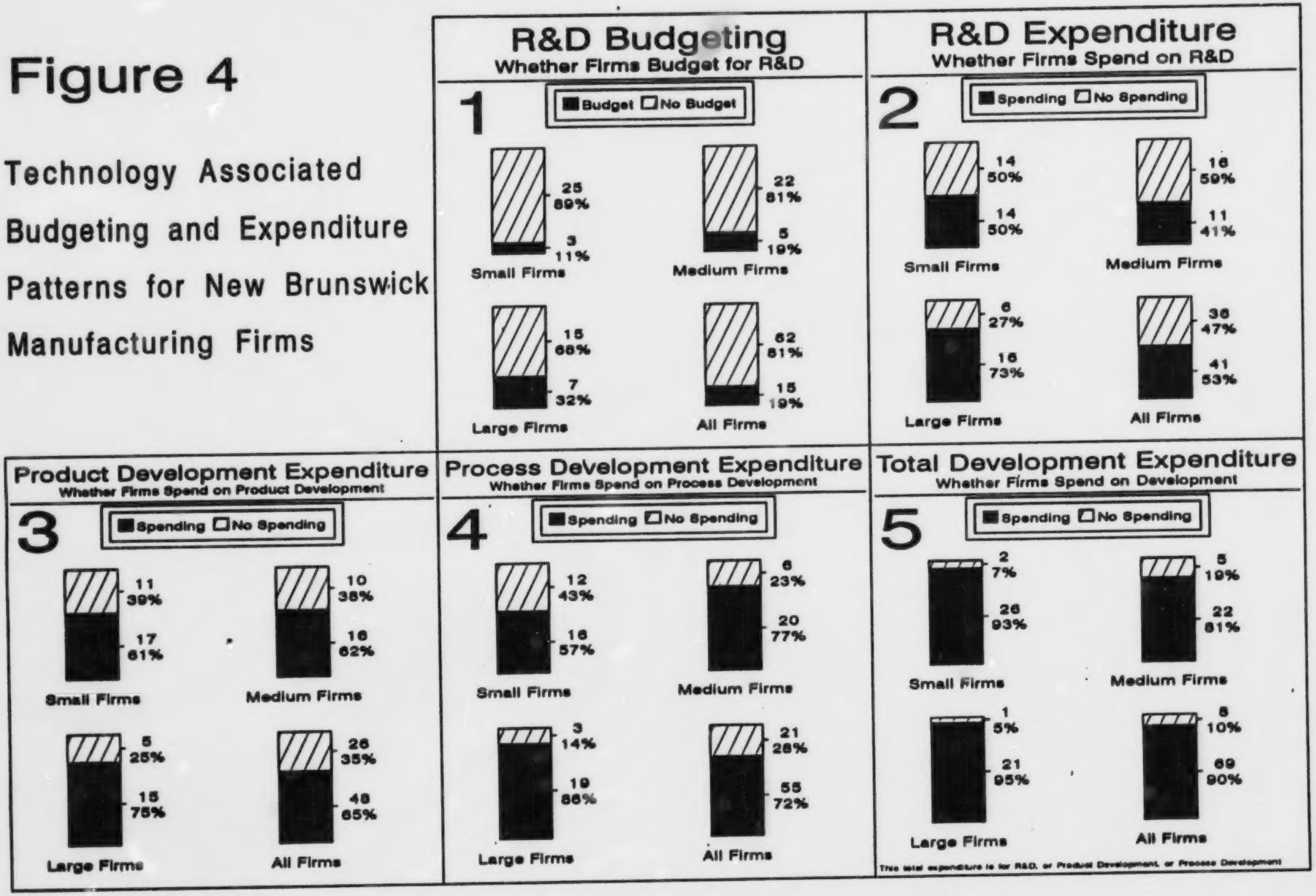
Panel 3 in Figure 4 shows numbers of firms claiming expenditures on product development. Product development spending was more common than what managers identified as R&D; 65% of firms claiming product development expenditures. All differences among firms based on size virtually disappear in Product Development with spending of 61%, 62% and 75% for small, medium, and large firms respectively. Panel 4 in Figure 4 shows numbers of firms claiming manufacturing process improvement expenditures. The overall percentage of firms making such expenditures increases yet again, this time to 72%. This increase is in the practices of medium and large firms. The number of small firms making process improvement expenditures is about the same as those making product development expenditures, 57% as compared to 61%. Larger firms indicate process improvement expenditures more commonly than they do product development expenditures, 77% as opposed to 62% for medium firms, and 86% as opposed to 75% for large firms.

When one considers whether or not firms spend on product development and process improvement, an even clearer picture emerges of commitment to activity associated with technological development. In Panel 5 one sees that 90% of all firms identified activity requiring spending on either R&D or product development or process improvement-- activities that involved bringing about changes in either the firm's product or its process technologies. Much of this spending was ad hoc and reactive. Technical problems in the installation of new equipment or in the maintenance of old equipment, for example, could lead to developmental activity.

All of this shows the reactive nature of New Brunswick manufacturing. In the main the firms in our sample react to circumstances to keep up in response to crises or opportunities. Spending on technology is a practical contingent matter. Circumstances, not an interest in and vision of technological opportunities, drive these firms to spend on technology.

Figure 4

Technology Associated Budgeting and Expenditure Patterns for New Brunswick Manufacturing Firms



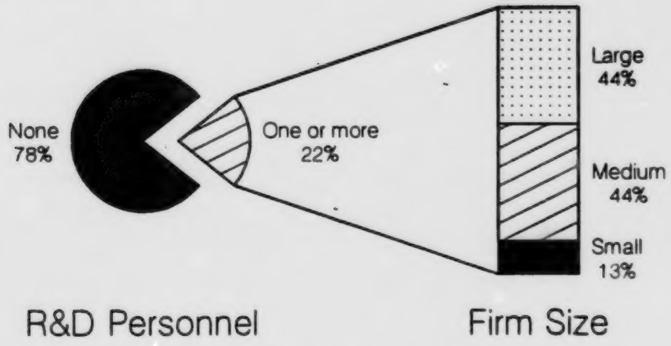
2.4.2 Technological Commitment: Specialization and Responsibility

Another indicator of the firm's commitment to technology is the extent to which personnel are specialized in functions associated with technology development. In Figure 5 the top pie chart shows the proportion of firms which have personnel whose major responsibility is technology development. This was considered to be anyone whose major responsibility is R&D in general, or product development in particular, or process and equipment development in particular. We asked firms to indicate personnel in the latter two cases since we wanted to broaden the concept of technology development as much as possible to include any personnel who were doing development work. Even with these broad distinctions we see that only 22% of firms had any personnel whose major responsibility was technology development. There is also a marked difference between small and larger firms. Very few (13%) small firms have any such personnel. In small firms they are far less likely to have sufficient human resources to assign such responsibilities to an employee or group of employees as the sole or even primary function.

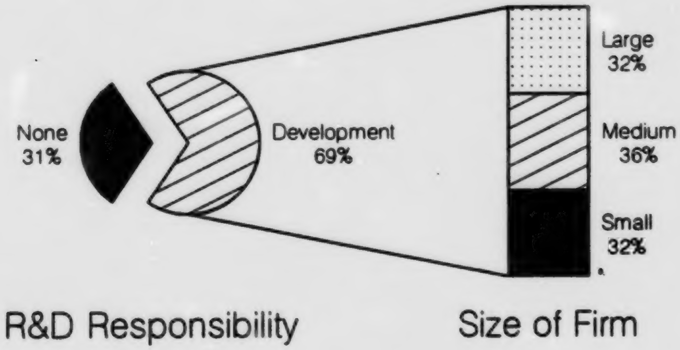
There is a dramatic difference in this pattern when the extent to which personnel are responsible for development functions is examined. It is important to consider not only whether there are personnel whose major responsibility is for these functions but also whether there is anyone with any responsibility for them. When we asked firms whether there was anyone in the firm responsible for any of these functions for any portion of their time, a different picture emerges. The vast majority of firms, 69%, have assigned some responsibilities for technological development. Further, the differences between firms by size disappears. On the one hand we can see how small firms have a "jack-of-all-trades" approach to covering the bases. On the other hand, in New Brunswick, this is not simply a characteristic of small firms. The changes are no less dramatic for large New Brunswick firms.

Figure 5 Technology Development Personnel and Responsibilities

Major Responsibility



Some Responsibility



2.4.3 Technological Commitment: Professionalization

A further dimension of technological commitment is the employment of professionals and specialists traditionally associated with developing new technologies and making familiar technologies work in the manufacturing and product development process. The survey elicited information about the role of a variety of engineers and technical specialists involved in production and/or product development. The "engineers" category includes the standard specialties recognized by the profession from civil engineers to mining engineers. The "technical specialists" category included a wide variety of professionals from microbiologists to information specialists and a wide variety of what are traditionally called trades and technicians like machinists, stationary engineers and retort operators. The distribution of engineers and technical specialists across respondent firms is given in Table 5.

Table 5 Engineers & Specialists by Firm Size

	FIRM SIZE			Total
	Small	Medium	Large	
Engineers & Specialists				
None	22	10	7	39
	56.4%	25.6%	17.9%	100.0%
	78.6%	37.0%	31.8%	50.6%
Engineers	1	4	2	7
	14.3%	57.1%	28.6%	100.0%
	3.6%	14.8%	9.1%	9.1%
Specialists	2	9	7	18
	11.1%	50.0%	38.9%	100.0%
	7.1%	33.3%	31.8%	23.4%
Both	3	4	6	13
	23.1%	30.8%	46.2%	100.0%
	10.7%	14.8%	27.3%	16.9%
Total	28	27	22	77
	100.0%	100.0%	100.0%	100.0%
	36.4%	35.1%	28.6%	100.0%

As would be expected, firm size is associated with the likelihood of finding specialists. However, even among the large firms only 36.4% employ at least one engineer, not significantly different than the 29.6% of medium sized firms that employ at least one engineer. With regard to all technical specialists including engineers 50.6 % of the respondents had none. Nearly 32% of the large firms had none-- not a single employee in any occupational group covered by either the engineer or technical specialists categories. These figures indicate a general profile of a lack of technological commitment by New Brunswick manufacturing firms.

2.5 Driving forces for Technology

New Brunswick firms are reactive, not proactive in their approach to technological change. As outlined in the sections above, New Brunswick firms typically do not invest in R&D. They are not technology developers who then seek markets for their new technology. Rather, they engage in a business which incidentally has technological dimensions. They acquire technology as a practical adjunct to their manufacturing.

Some of this dynamic can be seen in the way that firms explained their decision to undertake new technology development. Table 6 summarizes the reasons firms gave for undertaking product development. The factors most often cited as important in deciding to make product changes were market opportunity (90%) and customer demand (80%). Another market related factor, domestic competitors, was also often cited as important (62.5%). These responses clearly show the practical market orientation of firms. The other frequent responses were manufacturing efficiency and product improvement (both at 72.5%). The exploitation of new technology was cited as important in less than half the cases (42.5%). The efficiency and improvement factors could be read as related to technology if somewhat indirectly.

It is instructive to compare the motivations for product changes to those for process changes. Table 7 summarizes the reasons behind process change decisions. The importance of products as a reason for process development stands out; 73.8% of firms claim that product improvement was an important factor in the decision to develop a new process. The only other factor mentioned by more than half the firms was domestic competitors. As we have seen above, products and markets appear as the driving force in the development of innovations.

One important factor which comes out of both tables is the lack of importance of suppliers. As we will show later on in section 3, suppliers are central to the actual development and implementation of technology. However, they are not perceived as important for the initiation of technological change.

In the case of process innovations the exploitation of new technology and the reduction of labour costs were both cited as important reasons by 42.5% of firms. They were the third most frequently cited factors leading to process innovation. The relative frequency of new technology as an important driving force was greater in the case of process innovation than in the case of product innovation. Nevertheless, it remains of second order importance in both cases. It is true that technology follows rather than leads change in New Brunswick manufacturing.

Table 6 Reasons for Decision to Undertake Product Change

	FIRM SIZE			Total
	Small	Medium	Large	
Reasons for Decision				
Foreign competitors	6	3	3	12
	50.0%	25.0%	25.0%	100.0%
	35.3%	25.0%	27.3%	30.0%
Domestic competitors	10	8	7	25
	40.0%	32.0%	28.0%	100.0%
	58.8%	66.7%	63.6%	62.5%
New technology	8	5	4	17
	47.1%	29.4%	23.5%	100.0%
	47.1%	41.7%	36.4%	42.5%
Market opportunity	13	12	11	36
	36.1%	33.3%	30.6%	100.0%
	76.5%	100.0%	100.0%	90.0%
Customer demand	13	9	10	32
	40.6%	28.1%	31.3%	100.0%
	76.5%	75.0%	90.9%	80.0%
Supplier input	7	5	2	14
	50.0%	35.7%	14.3%	100.0%
	41.2%	41.7%	18.2%	35.0%
Manufacturing efficiency	14	9	6	29
	48.3%	31.0%	20.7%	100.0%
	82.4%	75.0%	54.5%	72.5%
Product improvement	13	10	6	29
	44.8%	34.5%	20.7%	100.0%
	76.5%	83.3%	54.5%	72.5%
Government regulations	7	3	4	14
	50.0%	21.4%	28.6%	100.0%
	41.2%	25.0%	36.4%	35.0%
Total	17	12	11	40
	100.0%	100.0%	100.0%	100.0%
	42.5%	30.0%	27.5%	100.0%

Table 7 Reasons for Decision to Undertake Process Change

	FIRM SIZE			Total
	Small	Medium	Large	
Reasons for Decision				
Foreign competitors.	5	3	5	13
....	38.5%	23.1%	38.5%	100.0%
....	33.3%	23.1%	35.7%	31.0%
Domestic competitors	10	7	8	25
....	40.0%	28.0%	32.0%	100.0%
....	66.7%	53.8%	57.1%	59.5%
New technology......	8	4	7	19
....	42.1%	21.1%	36.8%	100.0%
....	53.3%	30.8%	50.0%	45.2%
Labour reduction....	9	4	6	19
....	47.4%	21.1%	31.6%	100.0%
....	60.0%	30.8%	42.9%	45.2%
Energy reduction....	6	2	1	9
....	66.7%	22.2%	11.1%	100.0%
....	40.0%	15.4%	7.1%	21.4%
Capital requirement reduction........	6	2	1	9
....	66.7%	22.2%	11.1%	100.0%
....	40.0%	15.4%	7.1%	21.4%
Supplier input......	7	4	2	13
....	53.8%	30.8%	15.4%	100.0%
....	46.7%	30.8%	14.3%	31.0%
Product improvement.	12	8	11	31
....	38.7%	25.8%	35.5%	100.0%
....	80.0%	61.5%	78.6%	73.8%
Government regulations......	1	1	2	4
....	25.0%	25.0%	50.0%	100.0%
....	6.7%	7.7%	14.3%	9.5%
Total...............	15	13	14	42
....	100.0%	100.0%	100.0%	100.0%
....	35.7%	31.0%	33.3%	100.0%

2.6 How Firms Manage Technology

Typically New Brunswick firms do not manage technology. As seen above the development of technology is not planned or managed. Once firms have technology there is a similar pattern in that firms typically do not organize and plan what they will do with technologies.

2.6.1 The Protection of Technology

We asked firms how they protected their product and process technologies. Table 8 shows the results for products. We separated out patents and then asked firms if they protected technologies in any other way. In Table 8 we have combined the results to show the numbers of firms reporting patents or other protection, and to show a count of those firms who stated that they did not protect technology. Only two firms stated that they had patented product developments. The major other form of protection was also a form of intellectual property, namely, trademarks or brand names. Control of distribution and licensing arrangements were also mentioned under the other category.

Table 8 Protection of Product Technology

	FIRM SIZE			Total
	Small	Medium	Large	
Protection				
Patented product....	0	1	1	2
....	.0%	50.0%	50.0%	100.0%
....	.0%	8.3%	8.3%	5.0%
Protected other than by patents.......	2	1	4	7
....	28.6%	14.3%	57.1%	100.0%
....	12.5%	8.3%	33.3%	17.5%
No Protection.......	14	10	7	31
....	45.2%	32.3%	22.6%	100.0%
....	87.5%	83.3%	58.3%	77.5%
Total...............	16	12	12	40
....	100.0%	100.0%	100.0%	100.0%
....	40.0%	30.0%	30.0%	100.0%

A more extreme form of lack of active technology management surfaces in the case of process technologies. Table 9 shows that no firms took out patents and that only 1 firm indicated that it protected process technologies in any way. It was not clear what this other protection was in this case. The case studies turned up a few patents, trademarks and secrecy as process protection methods. In one case a machine which the company had designed and constructed for its sole use was hidden in a shed separated from the main manufacturing operation. In another, a modification to a standard milling machine was hidden from visitors in the same industry. Such incremental process improvements are difficult to commercialize. Their value to the innovating firm is limited to use on its shop floor.

Table 9 Protection of Process Technology

	FIRM SIZE			Total
	Small	Medium	Large	
Protection				
Patented process change	0	0	0	0
	.0%	.0%	.0%	.0%
	.0%	.0%	.0%	.0%
Protected other than by patents	0	0	1	1
	.0%	.0%	100.0%	100.0%
	.0%	.0%	6.7%	2.4%
No Protection	13	13	14	40
	32.5%	32.5%	35.0%	100.0%
	100.0%	100.0%	93.3%	97.6%
Total	13	13	15	41
	100.0%	100.0%	100.0%	100.0%
	31.7%	31.7%	36.6%	100.0%

2.6.2 Sharing Process Technology Information

The lack of protection of technologies outlined above is complemented by information sharing. Table 10 shows how frequently firms shared information about process changes. Sharing information on the process changes was quite common, with half the firms reporting that they had done so. There is a difference in these findings between small firms and others. Small firms were less likely to share. Small firms are local in their orientation. There are probably few firms asking to share their information.

Table 10 Process Technology Information Sharing

	FIRM SIZE			Total
	Small	Medium	Large	
Informal information sharing				
No..................	10	4	6	20
....	50.0%	20.0%	30.0%	100.0%
....	71.4%	30.8%	40.0%	47.6%
Yes.................	4	9	9	22
....	18.2%	40.9%	40.9%	100.0%
....	28.6%	69.2%	60.0%	52.4%
Total...............	14	13	15	42
....	100.0%	100.0%	100.0%	100.0%
....	33.3%	31.0%	35.7%	100.0%

2.7 Technology on the Margins: Conclusions

Many of the commitments of New Brunswick manufacturing firms are at the margin of the business enterprise. New Brunswick firms do not budget for R&D, nor do they have specialized or professionalized personnel. Very few New Brunswick manufacturing firms focus on technological investment, and when they do develop technology they do not typically treat it as a commodity which could be marketed. We found many New Brunswick firms to be fairly open in their approach to technology. New Brunswick firms react to local market circumstances. They are not driven by technological agendas. Technology is marginal, not central to the business enterprise.

Nevertheless, the findings do not show a lack of technology development activities. These activities are rather informal and dynamic. A good illustration of this can be found in an example from the metal fabrication industry. In one of our detailed field studies we investigated the case of a metal fabrication firm which has developed a substitute for a common piece of fishing gear which has traditionally been made of wood and netting. The innovating firm developed a metal wire replacement. In order to manufacture this product, the firm designed and built a metal shaping machine. Further, the firm had to find a way of insulating the wire from direct contact with sea water to avoid corrosion. A coating supplier was found and the coating process was adapted to the manufacturing process after much experimentation. This work has given the firm a technological lead and it now guards its manufacturing process through secrecy. What is interesting about this firm's innovation is that there was no dedicated R&D personnel or department within the firm. Machining personnel and managers took on the tasks and solved the problems in a practical fashion. This example demonstrates that significant innovation is possible without formal R&D commitments.

In developing strategies to enhance the technological capabilities of New Brunswick manufacturing we should not fall into the trap of thinking that a successful technological model is a rigid formal one with predetermined budgets, specialists, and professionals. Our reality is dynamic and informal. In developing strategies to enhance the we should look to increasing the effectiveness of this reality.

3 Technology Diffusion

This section concentrates on the question of "where New Brunswick owners\managers are turning to find new technology and how they conduct their search". In addressing the question of where and how owners and managers look for new technology we asked questions about product and process innovation in general, and specifically about new technologies involved in product and process innovations. We also asked questions about how managers found information about innovations and new technologies, and how the firms acquired actual competence in new technologies. These last questions included queries about where exactly the firm sourced the new technologies it acquired.

3.1 The Search for Information & Expertise

Managers may try to locate the information and expertise required in general for innovation and required specifically for the technological components of an innovation both inside the firm and outside. The following tables summarize the results of questions concerning the various sources of information and expertise. Table 11 gives results concerning process innovation information sources, and Table 12 does the same for product innovation. Table 13 outlines results for sources specifically of new process technology information, and Table 14 does the same for sources of information about new product technology. In discussing the meaning of these results we refer to findings from the CEO survey, findings that are not presented here in tabular form.

Table 11 Sources of Information and Expertise in Process Change

	Firm Size			Total
	Small	Medium	Large	
Senior management...	8	9	8	25
....	32.0%	36.0%	32.0%	100.0%
....	57.1%	69.2%	57.1%	61.0%
Shop floor..........	8	5	6	19
....	42.1%	26.3%	31.6%	100.0%
....	57.1%	38.5%	42.9%	46.3%
Plant maintanence...	8	7	8	23
....	34.8%	30.4%	34.8%	100.0%
....	57.1%	53.8%	57.1%	56.1%
Suppliers...........	8	8	6	22
....	36.4%	36.4%	27.3%	100.0%
....	57.1%	61.5%	42.9%	53.7%
Competitors.........	6	5	3	14
....	42.9%	35.7%	21.4%	100.0%
....	42.9%	38.5%	21.4%	34.1%
Parent corporation..	2	3	1	6
....	33.3%	50.0%	16.7%	100.0%
....	14.3%	23.1%	7.1%	14.6%
University..........	1	0	0	1
....	100.0%	.0%	.0%	100.0%
....	7.1%	.0%	.0%	2.4%
NB MTC, RPC or CADMI	0	1	0	1
....	.0%	100.0%	.0%	100.0%
....	.0%	7.7%	.0%	2.4%
Trade association or journal..........	1	2	2	5
....	20.0%	40.0%	40.0%	100.0%
....	7.1%	15.4%	14.3%	12.2%
Independent inventor	0	2	2	4
....	.0%	50.0%	50.0%	100.0%
....	.0%	15.4%	14.3%	9.8%
Personal contacts...	7	4	6	17
....	41.2%	23.5%	35.3%	100.0%
....	50.0%	30.8%	42.9%	41.5%
Total...............	14	13	14	41
....	100.0%	100.0%	100.0%	100.0%
....	34.1%	31.7%	34.1%	100.0%

Table 12 Sources of Information and Expertise in Product Change

	Firm Size			Total
	Small	Medium	Large	
Senior management...	12	6	10	28
....	42.9%	21.4%	35.7%	100.0%
....	75.0%	50.0%	90.9%	71.8%
Customers...........	14	10	9	33
....	42.4%	30.3%	27.3%	100.0%
....	87.5%	83.3%	81.8%	84.6%
R&D Depart or Equiv.	8	6	9	23
....	34.8%	26.1%	39.1%	100.0%
....	50.0%	50.0%	81.8%	59.0%
Shop floor..........	8	6	6	20
....	40.0%	30.0%	30.0%	100.0%
....	50.0%	50.0%	54.5%	51.3%
Sales force.........	6	7	8	21
....	28.6%	33.3%	38.1%	100.0%
....	37.5%	58.3%	72.7%	53.8%
Suppliers...........	8	4	3	15
....	53.3%	26.7%	20.0%	100.0%
....	50.0%	33.3%	27.3%	38.5%
Competitors.........	7	6	6	19
....	36.8%	31.6%	31.6%	100.0%
....	43.8%	50.0%	54.5%	48.7%
Parent corporation..	1	6	0	7
....	14.3%	85.7%	.0%	100.0%
....	6.3%	50.0%	.0%	17.9%
University..........	1	0	0	1
....	100.0%	.0%	.0%	100.0%
....	6.3%	.0%	.0%	2.6%
NB MTC, RPC or CADMI	3	2	0	5
....	60.0%	40.0%	.0%	100.0%
....	18.8%	16.7%	.0%	12.8%
Trade Assoc/journal	3	1	3	7
....	42.9%	14.3%	42.9%	100.0%
....	18.8%	8.3%	27.3%	17.9%
Independent inventor	3	0	1	4
....	75.0%	.0%	25.0%	100.0%
....	18.8%	.0%	9.1%	10.3%
Personal contacts...	7	6	5	18
....	38.9%	33.3%	27.8%	100.0%
....	43.8%	50.0%	45.5%	46.2%
No Source Important.	1	0	0	1
....	100.0%	.0%	.0%	100.0%
....	6.3%	.0%	.0%	2.6%
Total...............	16	12	11	39
....	100.0%	100.0%	100.0%	100.0%
....	41.0%	30.8%	28.2%	100.0%

Table 13 Process Technology Information Sources

Cells: Count Row %	SIZE			Total
	Small	Medium	Large	
Senior management...	8	8	8	24
....	33.3%	33.3%	33.3%	100.0%
....	57.1%	66.7%	57.1%	60.0%
Middle production management.......	8	6	8	22
....	36.4%	27.3%	36.4%	100.0%
....	57.1%	50.0%	57.1%	55.0%
R&D department......	5	1	6	12
....	41.7%	8.3%	50.0%	100.0%
....	35.7%	8.3%	42.9%	30.0%
Shop floor..........	8	3	3	14
....	57.1%	21.4%	21.4%	100.0%
....	57.1%	25.0%	21.4%	35.0%
Plant maintainance..	7	6	3	16
....	43.8%	37.5%	18.8%	100.0%
....	50.0%	50.0%	21.4%	40.0%
Suppliers...........	8	9	8	25
....	32.0%	36.0%	32.0%	100.0%
....	57.1%	75.0%	57.1%	62.5%
Competitors.........	5	6	4	15
....	33.3%	40.0%	26.7%	100.0%
....	35.7%	50.0%	28.6%	37.5%
Parent or affiliate.	0	1	2	3
....	.0%	33.3%	66.7%	100.0%
....	.0%	8.3%	14.3%	7.5%
University..........	1	0	0	1
....	100.0%	.0%	.0%	100.0%
....	7.1%	.0%	.0%	2.5%
MTC, CADMI, etc.....	0	2	0	2
....	.0%	100.0%	.0%	100.0%
....	.0%	16.7%	.0%	5.0%
Trade association, journal..........	2	2	3	7
....	28.6%	28.6%	42.9%	100.0%
....	14.3%	16.7%	21.4%	17.5%
Independent inventor	1	3	2	6
....	16.7%	50.0%	33.3%	100.0%
....	7.1%	25.0%	14.3%	15.0%
Personal contacts...	2	4	6	12
....	16.7%	33.3%	50.0%	100.0%
....	14.3%	33.3%	42.9%	30.0%
No Experts Indicated	1	0	0	1
....	100.0%	.0%	.0%	100.0%
....	7.1%	.0%	.0%	2.5%
Total...............	14	12	14	40
....	100.0%	100.0%	100.0%	100.0%
....	35.0%	30.0%	35.0%	100.0%

Table 14 Product Technology Information Sources

Cells: Count Row %	SIZE			Total
	Small	Medium	Large	
Senior management...	9	8	6	23
....	39.1%	34.8%	26.1%	100.0%
....	52.9%	72.7%	54.5%	59.0%
Middle production management.......	5	5	7	17
....	29.4%	29.4%	41.2%	100.0%
....	29.4%	45.5%	63.6%	43.6%
R&D department......	8	6	8	22
....	36.4%	27.3%	36.4%	100.0%
....	47.1%	54.5%	72.7%	56.4%
Shop floor..........	6	4	4	14
....	42.9%	28.6%	28.6%	100.0%
....	35.3%	36.4%	36.4%	35.9%
Plant maintainance..	3	1	1	5
....	60.0%	20.0%	20.0%	100.0%
....	17.6%	9.1%	9.1%	12.8%
Suppliers...........	6	4	6	16
....	37.5%	25.0%	37.5%	100.0%
....	35.3%	36.4%	54.5%	41.0%
Competitors.........	4	2	4	10
....	40.0%	20.0%	40.0%	100.0%
....	23.5%	18.2%	36.4%	25.6%
Parent or affiliate.	3	4	1	8
....	37.5%	50.0%	12.5%	100.0%
....	17.6%	36.4%	9.1%	20.5%
University..........	0	0	0	0
....	.0%	.0%	.0%	.0%
....	.0%	.0%	.0%	.0%
MTC, CADMI, etc.....	1	1	0	2
....	50.0%	50.0%	.0%	100.0%
....	5.9%	9.1%	.0%	5.1%
Trade association, journal..........	1	2	2	5
....	20.0%	40.0%	40.0%	100.0%
....	5.9%	18.2%	18.2%	12.8%
Independent inventor	2	0	2	4
....	50.0%	.0%	50.0%	100.0%
....	11.8%	.0%	18.2%	10.3%
Personal contacts...	7	6	7	20
....	35.0%	30.0%	35.0%	100.0%
....	41.2%	54.5%	63.6%	51.3%
No Product Source...	2	0	0	2
....	100.0%	.0%	.0%	100.0%
....	11.8%	.0%	.0%	5.1%
Total...............	17	11	11	39
....	100.0%	100.0%	100.0%	100.0%
....	43.6%	28.2%	28.2%	100.0%

The results above indicate that management sees internal information sources in general as more important than external ones. This was true for all information and expertise pertaining to the development of the innovation as well as for technological information and expertise. The one exception is the customer as a source of information when it comes to developing and implementing product innovations.

3.1.1 External sources of information & expertise

From Table 12 we can see that customers received the highest ratings (84.6%) for information relevant to product innovation. User and customer needs and wants appear crucial in getting ideas for new products and are taken into account in developing ideas into marketable products. It is interesting to note, however, that in spite of the importance attributed to customers as an information source for particular innovations 64% of all the firms in the survey do not do market research or have it done for them by outside consultants.

Three other important external sources of information and expertise with regard to both product and process innovation are:

suppliers
personal contacts
competitors.

3.1.1.1 Suppliers

Suppliers (firms supplying the manufacturing firm with raw materials, components, production equipment and services) in general were seen as the most important external source of information and expertise with regard to process innovation and process technology. From Tables 11 and 13 it is clear that over half the firms characterized them as an important source of information and expertise on some aspect of the innovation or on new technology required for innovation in general. In addition, suppliers were said to be an important source of general information on product innovation and as well an important specifically technological information source. We can see from Table 14 that suppliers were an important source of product technology information in 41% of the product innovations.

3.1.1.2 Competitors

From Table 12, we can see that competitors serve as an important external source of information on product innovation (48.7%). Firms monitor the products that their competitors introduce for ideas. Competitors are less important as a source of product technology information and expertise. Presumably for competitive reasons they are not forthcoming with such information. On the other hand, in spite of the tendency of firms to protect original innovations on the shop floor through secrecy, competitors are regarded as an important source of information on new process technology. In Table 13 37.5% of firms ranked them as important for process innovation.

These findings are consistent with other survey results which show that 52.4% of the firms surveyed on a process innovation have shared information about it with other firms. Seven of the detailed field studies document instances where manufacturing equipment suppliers encourage or arrange such visits as part of their sales efforts. Firms in industries with mature technologies subject to incremental improvements through experimentation on the shop floor are often willing to trade information with competitors, especially information about technology purchased from suppliers.

The importance and prevalence of contacts with competitors is underlined by results from the CEO survey. In 76.6% of cases firms indicated their firm belonged to industries in which visits to competitors' plants were accepted practice. Of these firms, 90.2% had at least one manager making such visits during the previous year. This is in a sample of firms where 82.9% had 4 or fewer managers. Furthermore, during the previous two years 64.5% of the firms had been contacted by other firms seeking technological information and expertise. Contacts with competitors and with other firms are an important source of technological information and expertise.

3.1.1.3 Personal Contacts

Personal contacts are of the same order of importance as information sources as are competitors and suppliers. Their relative importance varied depending on the type of innovation and the type of information and expertise under consideration. With regard to the technology involved in product innovation, Table 14 shows that 51.3% of those surveyed rated them as important sources compared to 41% and 25.6% for suppliers and competitors respectively. With regard to technology involved in process innovation, on the other hand, Table 13 shows that only 30% rated them as important compared to 62.5% for the suppliers and 37.5% for the competitors.

Personal contacts are understood to include individual managers' contacts with other individuals in the professional and business world. They may include contacts with counterparts in competing firms. The utility of this source is likely a function of the manager's business and professional experience. Older managers with varied experience in a number of firms, professional organizations, and industries are likely to have a wider network of contacts that may serve as informal sources of information, expertise, and advice concerning problems occurring in the development and implementation of an innovation. Several of the engineers and senior managers surveyed at length in the detailed field studies described information search routines that involved contacting a variety of former work colleagues and\or counterparts encountered through industry and professional meetings and activities. In the firm employing only young engineers with little or no previous job experience, the lack of contacts was sited as a problem. The network of personal contacts they could draw on was largely limited to professors and staff at their alma mater.

3.1.1.4 Industry and Trade Associations

In striking contrast to the importance of the three sources listed above, was the lack of importance attached to external sources whose formal mandate often includes information transfer. In Tables 12, 14, 11, and 13, industry & trade associations were cited as important sources of information in a range of only 12.2% to 17.9% of the product and process innovations. This was so even though 72.7% of all the firms surveyed belonged to at least one association of firms in a specific industry.

3.1.1.5 RPC, MTC's, CADMI & Universities

RPC, MTC's, CADMI, & Universities scored consistently low in their importance with regard to the innovations surveyed. In Tables 12, 14, 11, and 13 it is clear that, on the question of their importance as a source of information or expertise, all of these institutions did not receive more than a 12.8% importance rating. Usually it was 5% or less.

On the other hand, among senior management of all the firms surveyed, there was considerable recognition of RPC. From the general CEO interview, 79.2% of the senior managers indicated they had heard of RPC, and 55.8% indicated that their firm had used RPC's services in the past (see Tables and respectively). The discrepancy in the results between RPC's lack of importance with regard to the particular innovations we surveyed, and the substantial degree to which firms used its services in general, may be explained by the fact that RPC is mandated to help firms with a variety of problems beyond the development of process and product innovation. Some of the firms subject to the detailed field studies indicated that they had availed themselves of RPC services to deal with intractable technical problems arising in the course of existing operations including equipment repair.

Table 15 Awareness of New Brunswick Technology Sources

	Firm Size			Total
	Small	Medium	Large	
Aware of RPC	23	18	20	61
	37.7%	29.5%	32.8%	100.0%
	82.1%	66.7%	90.9%	79.2%
Aware of MTC	7	9	9	25
	28.0%	36.0%	36.0%	100.0%
	25.0%	33.3%	40.9%	32.5%
Aware of CADMI	3	8	7	18
	16.7%	44.4%	38.9%	100.0%
	10.7%	29.6%	31.8%	23.4%
Aware of Food Research Centre	4	6	10	20
	20.0%	30.0%	50.0%	100.0%
	14.3%	22.2%	45.5%	26.0%
Aware of Wood Science and Technology Centre	6	8	5	19
	31.6%	42.1%	26.3%	100.0%
	21.4%	29.6%	22.7%	24.7%
Aware of Science and Technology Information Service	4	10	9	23
	17.4%	43.5%	39.1%	100.0%
	14.3%	37.0%	40.9%	29.9%
Not Aware of these Sources	2	6	1	9
	22.2%	66.7%	11.1%	100.0%
	7.1%	22.2%	4.5%	11.7%
Total	28	27	22	77
	100.0%	100.0%	100.0%	100.0%
	36.4%	35.1%	28.6%	100.0%

Table 16 Use of New Brunswick Technology Sources

	Firm Size			Total
	Small	Medium	Large	
Used RPC	17	10	16	43
	39.5%	23.3%	37.2%	100.0%
	60.7%	37.0%	72.7%	55.8%
Used MTC	0	4	2	6
	.0%	66.7%	33.3%	100.0%
	.0%	14.8%	9.1%	7.8%
Used CADMI	0	1	1	2
	.0%	50.0%	50.0%	100.0%
	.0%	3.7%	4.5%	2.6%
Used Food Research Centre	1	1	3	5
	20.0%	20.0%	60.0%	100.0%
	3.6%	3.7%	13.6%	6.5%
Used Wood Science and Technology Centre	0	1	3	4
	.0%	25.0%	75.0%	100.0%
	.0%	3.7%	13.6%	5.2%
Used Science and Technology Information Service	1	2	4	7
	14.3%	28.6%	57.1%	100.0%
	3.6%	7.4%	18.2%	9.1%
Not Used these Sources	11	16	5	32
	34.4%	50.0%	15.6%	100.0%
	39.3%	59.3%	22.7%	41.6%
Total	28	27	22	77
	100.0%	100.0%	100.0%	100.0%
	36.4%	35.1%	28.6%	100.0%

MTC, CADMI and the Science & Technology Information Transfer Network received low awareness ratings. In Table 15 32.5%, 23.4% and 29.9% of the senior managers surveyed indicated they had heard of these institutions respectively. They had even lower use ratings. In Table 16, 7.8%, 2.6% and 9.1% of senior managers indicated they had used them respectively.

These nodes in the formally structured network for the transfer of technological information and expertise may be performing an effective service in supporting technological innovation in some manufacturing sectors. However, our survey indicates that they do not directly contribute to innovation in a broad constituency of New Brunswick manufacturing firms.

3.1.2 Internal Sources of Information & Expertise

As noted above, respondents in general consistently gave higher ratings to internal sources of information and expertise than to external sources. The exception was customers in the case of general information about product innovation. Senior management received more such ratings than other sources in the case of all product and process innovation information. Sales and R&D personnel outscored all external sources in the case of product innovation information, and middle management did so in the case of general process innovation information and was of lesser importance to only one external source of process technology information-- namely suppliers. This latter fact is remarkable when one realizes that many firms were too small to have much if any of a middle management function. Maintenance personnel were more important as a source of general process innovation information and expertise than any external source.

3.2 The Perception of Self-Sufficiency in Technology

The theme of respondents' belief in their own importance to the innovation process appears even stronger in their answers to questions about implementation of innovations and the actual acquisition of new technologies involved in innovations. The tables below give the results of questions in which respondents were asked how much of a part, all things considered, the firm played in developing and implementing either the process or product innovation in question as opposed to using outside sources and outside parties. In the survey of process innovations 69% of respondents (Table 17) and 70% in the survey of product innovations indicated they were either entirely or mostly responsible for the development and implementation of the innovations (Table 18).

Table 17 Process Development Independence by Size

	FIRM SIZE			Total
	Small	Medium	Large	
Who was responsible for process change				
The firm did it all	5 33.3% 33.3%	4 26.7% 30.8%	6 40.0% 42.9%	15 100.0% 35.7%
The firm did most of it	6 42.9% 40.0%	4 28.6% 30.8%	4 28.6% 28.6%	14 100.0% 33.3%
The firm did some of it and relied on outside sources for some of it	2 33.3% 13.3%	2 33.3% 15.4%	2 33.3% 14.3%	6 100.0% 14.3%
The firm relied mainly on outside sources	2 28.6% 13.3%	3 42.9% 23.1%	2 28.6% 14.3%	7 100.0% 16.7%
Total	15 100.0% 35.7%	13 100.0% 31.0%	14 100.0% 33.3%	42 100.0% 100.0%

Table 18 Product Development Independence by Size

	FIRM SIZE			Total
	Small	Medium	Large	
Who was responsible for the product change				
The firm did it all	11 55.0% 64.7%	5 25.0% 41.7%	4 20.0% 36.4%	20 100.0% 50.0%
The firm did most of it	1 12.5% 5.9%	3 37.5% 25.0%	4 50.0% 36.4%	8 100.0% 20.0%
The firm did some of it and relied on outside sources for some of it	3 33.3% 17.6%	3 33.3% 25.0%	3 33.3% 27.3%	9 100.0% 22.5%
The firm relied mainly on outside sources	2 66.7% 11.8%	1 33.3% 8.3%	0 .0% .0%	3 100.0% 7.5%
Total	17 100.0% 42.5%	12 100.0% 30.0%	11 100.0% 27.5%	40 100.0% 100.0%

There were even some respondents who acknowledged no role whatever for outside technology sources in innovations requiring technology new to the firm. Tables 19 and 20 below summarize the respondents' perceptions of the roles played by various technology sources in the innovations surveyed. Of the product innovations involving technologies new to the firm, 14.7% did not involve the firm's using any outside source of technology according to the respondent. In 13.5% of the process innovations requiring new technology, the firm is said to have used no outside source.

Table 19 Process Technology Sources

	FIRM SIZE			Total
	Small	Medium	Large	
Parent	0	1	2	3
	.0%	33.3%	66.7%	100.0%
	.0%	8.3%	14.3%	8.1%
Affiliate or subsidiary	1	3	1	5
	20.0%	60.0%	20.0%	100.0%
	9.1%	25.0%	7.1%	13.5%
Supplier	8	9	9	26
	30.8%	34.6%	34.6%	100.0%
	72.7%	75.0%	64.3%	70.3%
Joint venture partner	0	0	0	0
	.0%	.0%	.0%	.0%
	.0%	.0%	.0%	.0%
MTC, CADMI, etc	0	1	0	1
	.0%	100.0%	.0%	100.0%
	.0%	8.3%	.0%	2.7%
Inventor or consultant	2	2	3	7
	28.6%	28.6%	42.9%	100.0%
	18.2%	16.7%	21.4%	18.9%
Competitor	2	2	3	7
	28.6%	28.6%	42.9%	100.0%
	18.2%	16.7%	21.4%	18.9%
No Source Identified	1	3	1	5
	20.0%	60.0%	20.0%	100.0%
	9.1%	25.0%	7.1%	13.5%
Total	11	12	14	37
	100.0%	100.0%	100.0%	100.0%
	29.7%	32.4%	37.8%	100.0%

Table 20 Product Technology Sources by Firm Size

	FIRM SIZE			Total
	Small	Medium	Large	
Parent	2	3	1	6
	33.3%	50.0%	16.7%	100.0%
	14.3%	33.3%	9.1%	17.6%
Affiliate or subsidiary	1	1	0	2
	50.0%	50.0%	.0%	100.0%
	7.1%	11.1%	.0%	5.9%
Supplier	4	4	6	14
	28.6%	28.6%	42.9%	100.0%
	28.6%	44.4%	54.5%	41.2%
Joint venture partner	1	0	0	1
	100.0%	.0%	.0%	100.0%
	7.1%	.0%	.0%	2.9%
MTC, CADMI, etc	1	1	0	2
	50.0%	50.0%	.0%	100.0%
	7.1%	11.1%	.0%	5.9%
Inventor or consultant	3	1	2	6
	50.0%	16.7%	33.3%	100.0%
	21.4%	11.1%	18.2%	17.6%
Competitor	3	1	4	8
	37.5%	12.5%	50.0%	100.0%
	21.4%	11.1%	36.4%	23.5%
No Product Technology Sources	2	1	2	5
	40.0%	20.0%	40.0%	100.0%
	14.3%	11.1%	18.2%	14.7%
Total	14	9	11	34
	100.0%	100.0%	100.0%	100.0%
	41.2%	26.5%	32.4%	100.0%

These results indicate a general belief in technological self-sufficiency. The pattern of behavior associated with the belief has several elements:

1. The firm views itself as the primary agent of technological innovation and is therefore less likely to learn about and make use of outside sources of technological information and expertise. It is less likely to learn about and access outside sources of technology.

2. The kind of innovation which it can initiate and control itself tends to be incremental innovation-- adjustments and modifications of technologies with which it is familiar in the context of its current operations. Where it does innovate, it focuses on this sort of innovation rather than on radical innovation even where the latter may be justified or even required by competitive conditions.

3. The firm's frame of reference for comparing any innovations it undertakes tends to be parochial and limited. It therefore tends to hold exaggerated views about the newness or originality of its innovations.

This last element in the pattern is clearly shown by some of the survey's results with regard to respondent perceptions of newness and originality of the innovations. Most of the innovations that respondents scored as different from products or processes already in production or use in other firms seemed to the researchers not to have been at all original as described. One product innovation that is an example of this is the freezer on the boat mentioned above on page 12. Another example is no-cholesterol bakery products from a bakery on the Acadian Peninsula. Its innovation, no-cholesterol baked goods, may have been different from products from other bakeries in the region at the time, but it was hardly original in relation to Canadian bakeries or even Maritime bakeries. An example of a process innovation within this limited frame of reference, is the case of one wood products manufacturer who described a process as different from existing practice outside the firm. In this case, a process for a particular type of log milling on the firm's site replaced suppliers outside New Brunswick as the source of the firms milled logs. This was an effective importation of technology. The particular log milling process in question did not involve the establishment of a new technology to this type of manufacturing.

3.3 Suppliers as Sources of Technology

In cases where firms made use of outside sources of technology, suppliers were used most often as an external source -- a fact clearly apparent in Tables 19 and 20.

In the case of firms whose process innovations involved new technology, 70.3% sourced some or all of it from suppliers (see Table 19). Their importance as sources varied little in relation to the size of the innovating firm. The proportion of large firms sourcing new technology from suppliers was somewhat less than that of small and medium firms.

In the case of firms whose product innovation involved new technology, 41.2% overall sourced it from suppliers (see Table 20). This fact indicates that, the most frequently used outside source of product technology, suppliers, are of less importance as a source of product than of process technology. Their importance as a source also varies considerably in relation to the size of the innovating firm. Only 28.6% of the firms accessing new product technology did so from suppliers whereas 54.5% of the large firms did so.

The importance of suppliers as an outside source of new technology-- particularly manufacturing process technology-- is characteristic of mature industries, especially those making commodity type products. Such firms import new technology rather than developing it themselves, and they do so in the form of embodied technology. The new technology comes in the form of a piece of equipment or an industrial material or a component purchased from an industrial supplier. The supplier can also provide softer aspects of the technology (user manuals, expertise, trouble shooting, training of support personnel and equipment operators, etc.,).

The technology importing firm thereby reduces the risk inherent in developing new technologies for itself and pays supplier firms for the costs of developing it. Insofar as its technology is imported and is commercially available to other firms, it is not a source of competitive advantage except when the importing firm assumes the risk of being an early adopter of a new technology, or when it achieves advantage by being the first locally to import what is available elsewhere.

The most heavily used channel of technology importation into New Brunswick manufacturing as suggested by the data in the following tables is the channel between the rest of Canada and the Atlantic region. New Brunswick firms most likely look to suppliers, competitors, parents, affiliates, and other sources in central Canada. In the case of new process technologies the second most frequent location of sources is the United States. Manufacturing firms look to equipment and industrial materials suppliers in the U.S. and central Canada for much of the their new technology. In the case of product technologies local (either New Brunswick or Atlantic Canadian) sources of new technology play a greater role than in the case of new process technologies.

Table 21 Location of Product Technology Suppliers

	FIRM SIZE			Total
	Small	Medium	Large	
Suppliers' Location				
New Brunswick	6	4	3	13
	46.2%	30.8%	23.1%	100.0%
	37.5%	40.0%	33.3%	37.1%
Atlantic Canada outside NB	4	0	2	6
	66.7%	.0%	33.3%	100.0%
	25.0%	.0%	22.2%	17.1%
Canada outside Atlantic Region	9	5	5	19
	47.4%	26.3%	26.3%	100.0%
	56.3%	50.0%	55.6%	54.3%
United States	4	2	3	9
	44.4%	22.2%	33.3%	100.0%
	25.0%	20.0%	33.3%	25.7%
Other Locations	1	0	0	1
	100.0%	.0%	.0%	100.0%
	6.3%	.0%	.0%	2.9%
Total	16	10	9	35
	100.0%	100.0%	100.0%	100.0%
	45.7%	28.6%	25.7%	100.0%

Table 22 Location of Process Technology Suppliers

	FIRM SIZE			Total
	Small	Medium	Large	
Suppliers' Location				
New Brunswick	4	3	4	11
	36.4%	27.3%	36.4%	100.0%
	30.8%	25.0%	28.6%	28.2%
Atlantic Canada outside NB	2	0	2	4
	50.0%	.0%	50.0%	100.0%
	15.4%	.0%	14.3%	10.3%
Canada outside Atlantic Region	6	7	8	21
	28.6%	33.3%	38.1%	100.0%
	46.2%	58.3%	57.1%	53.8%
United States	6	3	6	15
	40.0%	20.0%	40.0%	100.0%
	46.2%	25.0%	42.9%	38.5%
Other Locations	0	1	1	2
	.0%	50.0%	50.0%	100.0%
	.0%	8.3%	7.1%	5.1%
No Suppliers Indicated	1	0	0	1
	100.0%	.0%	.0%	100.0%
	7.7%	.0%	.0%	2.6%
Total	13	12	14	39
	100.0%	100.0%	100.0%	100.0%
	33.3%	30.8%	35.9%	100.0%

What is striking about the data summarized in Tables 21 & 22 is the lack of use of new technology sources located outside North America. In the case of firms implementing new product technology, 1 small firm went to a source outside North America, and in the case of new process technology, only 1 medium sized and 1 large firm went to sources outside North America. This lack of use is striking when contrasted with the technology importation practices in 2 of the 10 firms that were the subjects of detailed field studies. These two systematically accessed European technology ahead of most North American and local competitors in ways that would give them some competitive advantage.

In many industries, like furniture and PVC products, European firms lead North American firms in certain technology areas. Such new technology tends to spread to American firms first, then to those in Central Canada, and finally to Maritime firms. The possibility exists for a New Brunswick manufacturer to short circuit the typical diffusion pattern by accessing a new European technology directly. This can be done through any of the various diffusion mechanisms, from licensing arrangements, to equipment purchases from suppliers, to surveying and copying product ideas that are not protected.

The problems which arise when firms source new technology off-shore in some cases may outweigh any competitive advantages gained. For example, one of the firms studied had some problems in obtaining technical support and service for some equipment purchased offshore. Distance from the equipment supplier and differences in system created difficulties which, while not prohibitive in this case, could well become so in other cases. However, we believe that the fact that so few New Brunswick firms in our sample went off-shore to source any new technology emphasizes how local their horizons are when it comes to searching for new technology.

3.4 Conclusions: Isolation and Diffusion

The majority New Brunswick firms are technologically isolated. Many engage in what we will later term tinkering, that is fiddling with local technologies to make them work without drawing on other experiences. In this context, the challenges of technology diffusion and effectiveness are great. New Brunswick manufacturing needs to broaden its horizons.

Three very significant findings emerge from the survey of how firms manage the search for technology and the sourcing of new technology. First, managers rated internal sources of technology information as more important than external sources. Second, they tended to view their firm's personnel as having the major roles in effecting technological innovation. Third, in cases where new technology required external sources, they viewed suppliers outside the Atlantic region as the predominant source.

These findings demonstrate an industrial sector in which management's horizons for technology management are parochial or local along several dimensions. First, technological innovation is mainly incremental and ad hoc. Much of it happens on the shop floor as existing devices are modified in response to crises or to exploit opportunities to gain marginal improvements in efficiency. This type of innovation tends to be done in house using personnel and resources whose primary functions lie in operating areas other than technological development. By managing this incremental technological change itself the firm acquires the sense that it is technologically self-sufficient. Its horizons are local in the sense that it sees itself, as an island unto itself technologically speaking.

Second, when the need for radical changes in process technology occur, firms tend to manage it by buying new technology in the form of new equipment and materials. They rely on suppliers to provide the new technology in an embodied form. Suppliers also supply technical support, but in fact the operating personnel in the firm must often perform a good deal of tinkering with new equipment to adapt it to its particular production situation. Such tinkering reinforces the firm's sense of technological self-sufficiency.

Third, the horizons of New Brunswick manufacturing firms are limited when it comes to sourcing new technology. They look for suppliers mainly in Canada west of the Atlantic Region. Only a few "technologically leading" firms systematically explore possibilities of importing new technology from off-shore sources ahead of its diffusion to Central Canada.

4 Workforce

One of the questions which directed the research of The Technology Diffusion Project was "To identify the factors that drive the successful adoption of technology by the New Brunswick workforce". This section of the report addresses this question along with other aspects of technology effectiveness related to the workforce.

4.1 The Adoption of Technology

Our analysis of worker adoption of new technology is limited to process technologies. Production workers are by definition associated with manufacturing processes, and the question of worker adoption of technology was explored in relation to these processes. Firms were asked what factors facilitated worker adoption and what factors inhibited worker adoption. The response rate was somewhat lower for this section of the questionnaire because of its lack of relevance for some respondents. There were 34 firms that responded on the successful adoption of technology and 24 firms that responded on the resistance to technology adoption. We will deal with technology adoption first.

The two most important reasons given by firms for the successful adoption of new process technologies by workers, were willingness to change and job security. Each of these reasons was cited as important by 20 of the firms (58.8%, see Table 23). Willingness to change and job security were closely followed by skills (55.9%) and interesting work (47.1%). Only 26.5% of firms mention pay incentives. The patterns are consistent across firm size with the exception of pay incentives. Pay incentives were cited as an important reason by only one small firm. For small firms, pay incentives, are a far less important factor than for large firms.

It is interesting that a similar pattern is evident in the reasons for not adopting new technology, or worker non-adoption, outlined in Table 24. Unwillingness to change, insufficient skills, and job insecurity were the factors most frequently cited as important for worker non-adoption (both 58.3%). A difference between forces for adoption and forces preventing adoption is evident in the extent to which the interesting nature of the work was a factor, down from 47.1% to 33.3% respectively. It appears that whether work is interesting is more of an incentive than a disincentive. Consistent with adoption facilitation, pay incentives were also not important for worker non-adoption. The percentages here are almost identical (26.5% and 25%). The only difference for this factor lies in consistency across firm size. As referred to above, in the case of worker adoption only one small firm mentioned pay. In the case of worker non-adoption only small and large firms mention a lack of pay incentives. No medium size firms indicated that lack of pay incentives was important. It is not clear why there should be this lack of consistency in the importance of pay incentives. It is likely the relatively small sample size for this factor contributes to these statistical fluctuations.

Table 23 Reasons Workers Adopt Technology

	FIRM SIZE			Total
	Small	Medium	Large	
Reasons for Adoption				
Willingness to change, helped adoption.........	7	6	7	20
....	35.0%	30.0%	35.0%	100.0%
....	58.3%	54.5%	63.6%	58.8%
Job security, helped adoption.........	8	7	5	20
....	40.0%	35.0%	25.0%	100.0%
....	66.7%	63.6%	45.5%	58.8%
Skills, helped adoption.........	6	6	7	19
....	31.6%	31.6%	36.8%	100.0%
....	50.0%	54.5%	63.6%	55.9%
Pay incentives, helped adoption..	1	4	4	9
....	11.1%	44.4%	44.4%	100.0%
....	8.3%	36.4%	36.4%	26.5%
Interesting work, helped adoption..	7	6	3	16
....	43.8%	37.5%	18.8%	100.0%
....	58.3%	54.5%	27.3%	47.1%
Importance of other.	0	0	1	1
....	.0%	.0%	100.0%	100.0%
....	.0%	.0%	9.1%	2.9%
Total...............	12	11	11	34
....	100.0%	100.0%	100.0%	100.0%
....	35.3%	32.4%	32.4%	100.0%

Table 24 Reasons Workers do not Adopt Technology

	FIRM SIZE			Total
	Small	Medium	Large	
What Hinders Workers				
Unwillingness to change, inhibited adoption.........	7	3	4	14
....	50.0%	21.4%	28.6%	100.0%
....	77.8%	50.0%	44.4%	58.3%
Jobs threatened, inhibited adoption.........	3	2	6	11
....	27.3%	18.2%	54.5%	100.0%
....	33.3%	33.3%	66.7%	45.8%
Insufficient skills, inhibited adoption.........	7	5	2	14
....	50.0%	35.7%	14.3%	100.0%
....	77.8%	83.3%	22.2%	58.3%
No pay incentives, inhibited adoption.........	3	0	3	6
....	50.0%	.0%	50.0%	100.0%
....	33.3%	.0%	33.3%	25.0%
Less interesting work, inhibited adoption.........	5	1	2	8
....	62.5%	12.5%	25.0%	100.0%
....	55.6%	16.7%	22.2%	33.3%
Total...............	9	6	9	24
....	100.0%	100.0%	100.0%	100.0%
....	37.5%	25.0%	37.5%	100.0%

The direct answers to the question of what drives workers to adopt technology are well laid out in Tables 23 and 24. According to firms, workers with a positive attitude, job security, and skills are more likely to adopt, and correspondingly those with a negative attitude, job insecurity, and lack of skills have trouble with technology adoption. The intrinsic interest of the work also has an effect, although more for adoption than non-adoption. Surprisingly, economic incentives do not appear as important factors. Willingness and unwillingness are most likely related to the other factors. Job security and skills are a tangible basis for a good attitude, although there can be extraneous factors. We will concentrate the discussion in the remainder of this section on these more tangible and important factors of skill and job security.

4.2 Process Changes and Their Effects on Skills

There are many different skills. We have grouped skills under the general categories of physical strength, manual dexterity, technical ability, literacy, and computer skills. Table 25 summarizes responses. We asked respondents to assess whether there was a major decrease, some decrease, no change, some increase, or a major increase in the skills required of workers as a result of the process change. The results in Table 25 are dramatic in that the overwhelming response was no change. In the cases of strength, literacy, and computer skills, over 80% said there had been no change. In the cases of dexterity and technical skills, the no change response was closer to half with 55% and 47.5% respectively. But there were changes, and these changes have important cumulative effects.

It is important to remember that the changes being assessed are for the effects of one process change. The changes which emerge are not usually dramatic on one occasion, but the persistence and direction of change will add up over time. The direction of this change is clear. In no case is physical strength on the increase. As a matter of fact, in 12.5% of cases there was a major decrease in the requirement for physical strength, and in 7.5% of the cases there was some decrease. Physical strength, a worker characteristic associated with traditional primary and manufacturing industries, is on the decline.

The increased skill demands on the New Brunswick workforce are evident in the case of manual dexterity. This traditional skill is becoming more important. Fully 35% indicate increases in dexterity requirements as the result of this one change, whereas, 10% of firms indicate some decrease in dexterity requirements.

There were no decreases in technical ability. Over half (52.5%) of the firms note increases in technical ability requirements. Technological skill requirements are markedly on the increase.

In 20% of cases, firms indicated that literacy demands had increased. The least amount of increase noted for newer skills was in relation to computing where only 13.2% of firms indicated an increase. Few of the manufacturing innovations surveyed involved computerization. Overall, the definite trend is in the direction of increasing requirements even though the rate of increase for some skills is slower than for others.

These findings go against the general trend claimed by some observers that in large scale assembly line manufacturing in industrialized societies there is a deskilling of the traditional workforce. Perhaps, since New Brunswick is not involved in large scale assembly line manufacturing this does not show up as a trend. In the marginal economy of New Brunswick, where most firms are small, the workplace is getting more, not less complex. These dynamics require more detailed study of the workplace. This goes beyond what can be analyzed by the questionnaire and interview data in this study.

Table 25 Process Change Effects on Skills

	Major decrease	Some decrease	No change	Some increase	Major increase
Physical strength					
Count.............	5	3	32	0	0
Row Percent.......	12.5%	7.5%	80.0%	.0%	.0%
Manual dexterity					
Count.............	3	1	22	13	1
Row Percent.......	7.5%	2.5%	55.0%	32.5%	2.5%
Technical ability					
Count.............	0	0	19	18	3
Row Percent.......	.0%	.0%	47.5%	45.0%	7.5%
Literacy					
Count.............	0	0	32	7	1
Row Percent.......	.0%	.0%	80.0%	17.5%	2.5%
Computer skills					
Count.............	1	0	32	5	0
Row Percent.......	2.6%	.0%	84.2%	13.2%	.0%

4.3 Process Change and its Effects on Education Requirements

One of the formal ways in which skill changes can be manifest is in the educational requirements of workers. Table 26 outlines the educational level of workers after the process change thereby indicating whether there has been a change in level of educational requirements. The strong message is that in no case has there been a decline in educational requirements. When we look at Table 26 we see that all changes in educational requirements were increases to High School qualifications or above. The changes have been higher up the educational qualification scale. One firm indicated a change up to some high school but it is only when we go up to college or trade school diploma level that we see any significant changes. Three or about 9% of firms noted an increase to college or trade school. It is important to note here that no firms required university qualifications for their production workforce.

Although minor as compared to skills, the change in education is real. It is a mistake to equate formal education with skill. However, the results suggest that gradually the educational requirements of the New Brunswick workforce are shifting toward the need for more formal training. This shift is gradual but will be, given the results on skills above, persistent. Gradual and persistent change must be met on a day to day level with an upgrading of the workforce.

Table 26 Worker Education Level After Change by Educational Change

	Change in education of line workers			Total
	Increase	No change	Decrease	
Educational Level				
Grade school	0	8	0	8
	.0%	100.0%	.0%	100.0%
	.0%	26.7%	.0%	23.5%
Some High School	0	7	0	7
	.0%	100.0%	.0%	100.0%
	.0%	23.3%	.0%	20.6%
High School diploma	1	11	0	12
	8.3%	91.7%	.0%	100.0%
	25.0%	36.7%	.0%	35.3%
Some College or Trade School	0	3	0	3
	.0%	100.0%	.0%	100.0%
	.0%	10.0%	.0%	8.8%
College or Trade School diploma	3	1	0	4
	75.0%	25.0%	.0%	100.0%
	75.0%	3.3%	.0%	11.8%
Some University	0	0	0	0
	.0%	.0%	.0%	.0%
	.0%	.0%	.0%	.0%
University	0	0	0	0
	.0%	.0%	.0%	.0%
	.0%	.0%	.0%	.0%
Total	4	30	0	34
	100.0%	100.0%	.0%	100.0%
	11.8%	88.2%	.0%	100.0%

4.4 Meeting Skill Demands

How do firms cope with shifting skill demands? Table 27 summarizes the possibilities. The first possibility is to hire skilled workers to deal with the new technology. Only two firms indicated that they had taken this option. More common was the second possibility of training new workers. Fully 48.1% of firms which had shifting skills indicated that they had trained new workers as a way of dealing with the skill requirements of the changed technology. However, the strategy most frequently pursued (81.5%) was to retrain existing workers.

How workers were retrained is summarized in Table 28. On the job training was done in 92.3% of cases. Also significant is the fact that 42.3% did this training formally in house. Only 1 firm went outside for formal training of its employees.

Table 27 How Skill Demands Are Met

	FIRM SIZE			Total
	Small	Medium	Large	
Skill Demands Met				
Hire skilled workers	1	1	0	2
	50.0%	50.0%	.0%	100.0%
	11.1%	10.0%	.0%	7.4%
Train new workers	3	5	5	13
	23.1%	38.5%	38.5%	100.0%
	33.3%	50.0%	62.5%	48.1%
Retrain existing workers	6	9	7	22
	27.3%	40.9%	31.8%	100.0%
	66.7%	90.0%	87.5%	81.5%
None Indicated	1	0	0	1
	100.0%	.0%	.0%	100.0%
	11.1%	.0%	.0%	3.7%
Total	9	10	8	27
	100.0%	100.0%	100.0%	100.0%
	33.3%	37.0%	29.6%	100.0%

Table 28 How Workers are Trained

	FIRM SIZE			Total
	Small	Medium	Large	
How Training is Done				
On the job training.	8	9	7	24
....	33.3%	37.5%	29.2%	100.0%
....	100.0%	90.0%	87.5%	92.3%
Formal training inhouse..........	4	3	4	11
....	36.4%	27.3%	36.4%	100.0%
....	50.0%	30.0%	50.0%	42.3%
Formal training outside..........	0	1	0	1
....	.0%	100.0%	.0%	100.0%
....	.0%	10.0%	.0%	3.8%
No Training Indicated........	0	0	0	0
....	.0%	.0%	.0%	.0%
....	.0%	.0%	.0%	.0%
Total...............	8	10	8	26
....	100.0%	100.0%	100.0%	100.0%
....	30.8%	38.5%	30.8%	100.0%

When the findings for meeting skill demands and retraining are compared to the difficulties that firms claim to have with product and process development, it is clear that skill development is an internal matter. Firms were asked to rate the difficulties they had in the development of new products and new processes. Firms rated a range of difficulties. These are summarized in Table 29 and Table 28. In the case of product development, technical areas (51.4%) and acquiring skilled personnel (48.6%) were the two most common answers. In the case of processes, acquiring skilled personnel drops to third (32.4%) behind technical areas (43.2%) and financial difficulties (37.8%). Acquiring skilled personnel is a significant difficulty. Perhaps this is one of the factors which has led New Brunswick manufacturing to rely so heavily on the internal development and training of employees. This apparent deficiency in the skilled labour market need not be seen as a problem given the type of incremental shop floor innovation which predominates among surveyed firms. Typically, a technological innovation in a New Brunswick firm does not require radical changes in workers' skills that cannot be met by internal retraining and on the job training.

However, cumulatively, the development of technologies in New Brunswick manufacturing results in a gradual upgrading of workforce skill requirements. Presumably, this upgrading would provide opportunities for employees and hence improve interest and morale. A situation where skill advancement is filled through recruitment would provide no opportunity for employees and could engender opposition to technology. These implications and dynamics deserve detailed study of the effects of technology on the shop floor.

Table 29 Difficulties with Product Change

	FIRM SIZE			Total
	Small	Medium	Large	
Change Difficulties				
Financial dificulties......	5	5	3	13
....	38.5%	38.5%	23.1%	100.0%
....	35.7%	41.7%	27.3%	35.1%
Difficulty finding suppliers........	7	4	5	16
....	43.8%	25.0%	31.3%	100.0%
....	50.0%	33.3%	45.5%	43.2%
Technical areas difficulties.....	6	6	7	19
....	31.6%	31.6%	36.8%	100.0%
....	42.9%	50.0%	63.6%	51.4%
Difficulties finding outside expertise	4	2	5	11
....	36.4%	18.2%	45.5%	100.0%
....	28.6%	16.7%	45.5%	29.7%
Acquiring skilled personnel........	7	6	5	18
....	38.9%	33.3%	27.8%	100.0%
....	50.0%	50.0%	45.5%	48.6%
Government difficulties.....	4	1	5	10
....	40.0%	10.0%	50.0%	100.0%
....	28.6%	8.3%	45.5%	27.0%
Marketing...........	2	5	3	10
....	20)0$	50.0%	30.0%	100.0%
....	14.3%	41.7%	27.3%	27.0%
No Product Difficulties.....	1	3	2	6
....	16.7%	50.0%	33.3%	100.0%
....	7.1%	25.0%	18.2%	16.2%
Total...............	14	12	11	37
....	100.0%	100.0%	100.0%	100.0%
....	37.8%	32.4%	29.7%	100.0%

Table 30 Difficulties with Process Change

	FIRM SIZE			Total
	Small	Medium	Large	
Change Difficulties				
Financial dificulties	5	3	6	14
	35.7%	21.4%	42.9%	100.0%
	38.5%	27.3%	46.2%	37.8%
Difficulty finding suppliers	5	0	2	7
	71.4%	.0%	28.6%	100.0%
	38.5%	.0%	15.4%	18.9%
Technical areas difficulties	5	4	7	16
	31.3%	25.0%	43.8%	100.0%
	38.5%	36.4%	53.8%	43.2%
Difficulties finding outside expertise	5	3	2	10
	50.0%	30.0%	20.0%	100.0%
	38.5%	27.3%	15.4%	27.0%
Acquiring skilled personnel	4	6	2	12
	33.3%	50.0%	16.7%	100.0%
	30.8%	54.5%	15.4%	32.4%
Government difficulties	1	3	1	5
	20.0%	60.0%	20.0%	100.0%
	7.7%	27.3%	7.7%	13.5%
No Difficulties	3	2	3	8
	37.5%	25.0%	37.5%	100.0%
	23.1%	18.2%	23.1%	21.6%
Total	13	11	13	37
	100.0%	100.0%	100.0%	100.0%
	35.1%	29.7%	35.1%	100.0%

4.5 Job Security

Job security was one of the two most important reasons for the successful adoption of new process technologies. One direct manifestation of job insecurity is the layoff of workers. We asked firms whether they had laid off any employees as a result of the manufacturing process change. Table 31 shows the answer to this question by the level of education of the worker. From our analysis of skills and education we would expect that layoffs would occur with workers with fewer educational qualifications. This is what Table 31 shows. There were few layoffs due to technology, but in the cases where they occur, they do so in the grade school category and in the high school diploma category. No layoffs occur above this level. As skill requirements escalate, those at the bottom of the skill and educational hierarchy lose out. In New Brunswick this trend is gradual and is probably mitigated by the reliance on shop floor and in house training.

Table 31 Education Level by Layoffs For Process Changes

	Lay off line workers		Total
	No	Yes	
Education Level			
Grade school........	7	1	8
....	87.5%	12.5%	100.0%
....	22.6%	33.3%	23.5%
Some High School....	7	0	7
....	100.0%	.0%	100.0%
....	22.6%	.0%	20.6%
High School diploma.	10	2	12
....	83.3%	16.7%	100.0%
....	32.3%	66.7%	35.3%
Some College or Trade School.....	3	0	3
....	100.0%	.0%	100.0%
....	9.7%	.0%	8.8%
College or Trade School diploma...	4	0	4
....	100.0%	.0%	100.0%
....	12.9%	.0%	11.8%
Total...............	31	3	34
....	100.0%	100.0%	100.0%
....	91.2%	8.8%	100.0%

4.6 Workforce: Conclusions

Two important points concerning workforce issues emerge from our survey of product and process technology innovations.

First, the workforce has been largely successful in adapting to the changes required of it by the sort of technological innovation it has faced so far. It is facing increasing skill requirements. These increases are gradual but persistent and highlight the long term investment needed in skills and training. Managers have noted difficulties in acquiring skilled personnel in many cases but seem to regard themselves as having been successful so far in overcoming the difficulties by upgrading worker skills through in house programmes. This is important both for the effectiveness of firms and for the wellbeing of the worker. Firms and individuals with fewer skills suffer in the long term. This situation is in part the result of the industrial mix of New Brunswick. There are no large scale manufacturing assembly plants in New Brunswick. This is the type of highly skilled workforce which is being displaced by technology in other economies.

Second, the success of the workforce so far in the face of technological innovation in the manufacturing sector may in large part be a function of the industrial mix in New Brunswick. This sector is dominated by industries with mature technologies in which technological innovation is usually incremental and ad hoc. If the industrial mix shifts to more high tech industries, which are characterized by frequent radical innovation in either process or product technology or both, the present skill levels of the New Brunswick workforce could well become a severe constraint on our ability to compete in the global economy. This possibility is highlighted by detailed field studies of the three firms from the group of 10 in industries involving sophisticated product technology, involving radical product development, and requiring workers with university and community college credentials in specialized technical areas. Their major difficulty beside financing was the acquisition of reliable skilled personnel. Unlike the typical New Brunswick manufacturing firm they found it impractical to solve their skill acquisition problems by retraining their existing workforce. This type of problem with workforce adoption of new technology could become more prevalent.

5 Technology Effectiveness

In this concluding section we outline a model of technology development which identifies Technology Development Activities (TDA's) and the Technology Development Network (TD-NET) within which firms manage these activities. Based on this analysis we make recommendations for public policy.

5.1 Technology Effectiveness in All Sectors

New Brunswick's manufacturing and processing sector is dominated by natural resource based industries like forest and fish products. However, technology management and technological innovation take place in a variety of industries from consumer goods to resource based industries employing a range of technology types from sophisticated to simple, and from emerging to mature and stable technologies. The range of technologies in New Brunswick is a function of the mix of New Brunswick manufacturing industries.

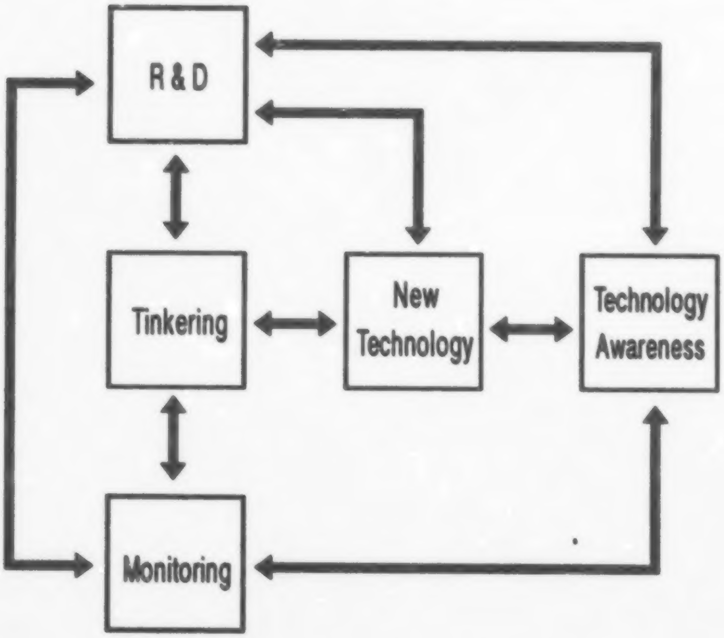
This report assumes the current industrial mix in the province and addresses the issues of managing the technologies inherent in that mix. Although changing the industrial mix changes the technological mix, technology development is an issue in mature, in simple and even in stable technologies as well as in emerging and sophisticated ones. Issues of technological effectiveness arise in every industry.

Technology is always relevant to business development. The importance of technological effectiveness is not restricted to a few high tech sectors. Correspondingly, the solution to technological effectiveness is not to get out of established industry. This simply avoids the issue of technology effectiveness across all sectors. It is important to diversify an economy across a range of sectors, but this diversification does not eliminate the task of making all sectors of the economy technologically effective. The approach we have taken in this report is to confront the reality of the industrial mix in New Brunswick and to come to terms with what is necessary and appropriate for this situation.

5.2 Technology Development Activities (TDA's) and Interactions

In this final analysis we concentrate on three major technology development actions (TDA's); **R&D, Tinkering, and Monitoring.** We demonstrate how these activities interact with two factors, **Technology Awareness** and **New Technology.** The structure of these interactions is outlined in Figure 6. This figure shows all five factors. It is important to note that the lines of influence in the **Technology Development and Diffusion Network (TEDD-NET)** are bidirectional. For example, R&D can lead to New Technology, and, New Technology can lead back to R&D. The interactions are dynamic. We will discuss the parts of the **TEDD-NET** in turn.

Figure 6
Technology Development & Diffusion Network (TEDD-NET)



5.2.1 Research and Development

Research & Development is directed at fundamental understanding and control. It is actually a range of activities. At one end is fundamental non-directed research, in which the aim is simply the understanding of natural or physical processes without any clear idea for controlling such processes through devices other than those employed in the laboratory. At the other end of the spectrum are development activities carried on with increasingly definite ideas of how such processes might be controlled by devices that can be usefully employed by customers or by a firm's own production function. R&D tends to be associated with formally qualified scientists, engineers, and technicians.

We found some evidence of R&D activity among New Brunswick manufacturing firms, but not evidence of activity at the research end of the R&D spectrum. Rather, it was activity of a developmental nature. In 7 of the firms subject to the detailed field studies we found process or product development activity. In four of the firms it was carried out primarily in 'labs' (i.e., physical premises devoted mainly to and equipped for R&D) by personnel for the most part with technical and professional qualifications whose primary job responsibility was technology development activity. In the other three it was carried out entirely in premises used on a temporary or ad hoc basis for the development project (like machine shops or on the factory floor) by personnel whose primary job responsibilities lay in other operational areas and only a few of whom had professional and technical qualifications.

In New Brunswick, R&D is undertaken by a few small technology based firms and some large corporations. The small firms of this type are in the high risk business of claiming a new niche or selling an idea to larger producers in the industrial sector of which they are a part. This innovative component of the economy is important, but is clearly not a model for most firms which are engaged in established businesses. The large firms which do R&D have technical staff. And even here there is little indication of a proactive R&D strategy. In these large organizations R&D can get done because there is enough of a technical infrastructure in the organization to make R&D a spinoff of what we will describe below as "tinkering".

In short, R&D has not been common among New Brunswick firms. It has not been a realistic option for most New Brunswick firms. There are other routes to technology development.

5.2.2 Tinkering

We will use the term Tinkering to refer to situational shop floor technical actions. Maintaining and adapting machinery is a clear case of Tinkering. The transfer and adaption of technologies involves a great deal of Tinkering. The machine shop is perhaps the clearest manifestation of Tinkering in a manufacturing firm. It is crucial that a firm have access to effective Tinkering capacity. All technology development and transfer fails without it. Tinkering is the bread and butter TDA. In New Brunswick, the majority of development projects involve Tinkering. This is not as clearly identifiable, nor as glamorous, as R&D.

There is a continuum between R&D and Tinkering. In one example from our study, a New Brunswick manufacturer was trying to get a coating powder to adhere to a metal surface. In this case an R&D strategy would have been to investigate the property of these powders and to understand the mechanism behind the adhesion process. Tinkering would be to engage in trial and error adjustments. The New Brunswick firm engaged in trial and error tinkering. What many firms described to us as R&D is actually tinkering.

Science and research based technologies have gained the limelight in the latter half of the twentieth century. The fusion of science with industrial technology is a truly remarkable phenomenon. However, we must not lose site of the fact that shop floor tinkering and craft experience persists and may be responsible for much innovation. Further, even highly scientific research enterprises include effective Tinkering. Globally, it is clear that those firms which were involved in active research programs also engaged in Tinkering to make the final product or process work. Tinkering is doubly important, both as part of science based R&D, and by itself.

5.2.3 Monitoring and Awareness

Monitoring is the observation of technology in the TEDD-NET. We discovered monitoring as a "research" strategy in the course of our study of firms. As it turned out what some firms characterized to us as R&D was really monitoring.

On a number of occasions interviewees responded that they did "R&D", but their explanation of these activities made it clear that what was meant was that they monitored the technologies available elsewhere. One extreme example of this comes from a firm where an employee was sent on "holiday" to the United States (he had a mobile home) to a location where there was a cluster of activity in that manufacturing sector. The "R&D" work described was inspecting job sites and seeing whether there were any techniques which could be adapted by the the firm back in Canada. Another example came from a firm which aggressively monitored product design trends in European kitchen cabinetry. Senior management attended trade shows, visited both foreign and Central Canadian manufacturers, and struck deals with them to distribute their products here with the explicit understanding that it would eventually manufacture these products. It then experimented in the plant with ways of manufacturing these same and similar products, developing its process skills through trial and error. Its explicit strategy was one of avoiding invention and original design. Rather, it was one of systematically monitoring designs elsewhere and then 'reverse engineering' them to attain the capability of reproducing them. In listing its R&D activities and in calculating for us the amounts it spent on R&D in the prior year, management included the costs of trips to trade shows and to other manufacturers (i.e., the general intelligence gathering activities) as well as the costs of the tinkering and development work done in figuring out how to manufacture the products being copied.

In the context of a global economy and the diversity of technology, it is clear that monitoring is a critical activity for technological effectiveness. Monitoring is critical for even research intensive firms where there can be keen competition at the leading edge of scientific development. Regardless of the research profile of a firm, Monitoring is a central component in the development of best practice. The question lies in where Monitoring can be most effectively carried out. Government should play an active role in this activity. We will discuss this further, but the essential point is that Monitoring, like other TDA's need not be performed by the individual firm. It could be carried out, on the firms behalf, by outside players in both the private and public sector.

Monitoring leads to awareness. In Figure 6 we have separated out the state of Technology Awareness from Technology Monitoring. Monitoring is not the only source for Awareness. It can result from R&D and from contact with New Technology, or as we will discuss later, other actors in the system can transfer Awareness to firms.

5.3 Technology Development and Diffusion Networks (TEDD-NETs)

All network relationships (Figure 6 on page 84) are potentially two sided interactions - not unidirectional flows. For example, Tinkering can lead to New Technology. However, New Technology may generate Tinkering in the adaption and implementation process, for example, in the case of new production equipment. Experiences with adaption could then lead back to New Technologies. Similar interactions can occur between R&D and New Technology. The essential relations are potentially interactive. This potential may be more or less realized in practice.

Tinkering can also lead to R&D activities. This can most clearly be seen in the firms which after Tinkering with a problem call on outside R&D capacity. This R&D capacity could be held in suppliers, RPC, government, or universities. As indicated by our research this pattern of reliance is common in New Brunswick.

It is important to emphasize that at the level of the firm, in the vast majority of cases, a tinkering strategy is effective. As the Tinkering driven interactions above indicate, it is necessary for firms to have access to R&D. However, in considering the overall network it may not make sense to have R&D located within the firm. Other public and private sector actors can be good sources of R&D support. In fact the flexibility of the location of R&D capacity can be a strength of the network.

TEDD-NET's are flexible and dynamic in their structure. Firms may have complete networks within them which are supplemented by broader TEDD-NETs. Alternatively, firms may engage in only some limited TDAs and rely totally on external networks for development. These dynamics are outlined below.

5.4 Proactive and Reactive Network Strategies Within the Firm

Firms may take a proactive stance or a reactive stance or a combination of both in performing the three TDA's just discussed. In taking a proactive stance, the firm seeks to influence its technological environment and to anticipate the technological opportunities and threats its environment may present. It seeks to create opportunities for itself. In a reactive stance the firm waits for its environment to present it with technological opportunities and problems and only reacts when a response is required. Proactivity and Reactivity are stances which a firm can take in relation to any TDA. R&D is not necessarily more proactive than Monitoring or Tinkering. An ideal for technology effectiveness is a proactive stance in relation to all three TDA's. Below, we outline some illustrations of Proactivity and Reactivity in R&D, Tinkering and Monitoring.

5.4.1 Proactive and Reactive R&D

Proactive R&D creates new products and processes. It exploits opportunities. Reactive R&D is a response to a variety of situations, including unforseen circumstances and crises, as well as invention and innovation on the part of competitors. It is directed toward discovering how the innovation works or how it may be duplicated. In cases where the innovation is based on proprietary knowledge that is protected through secrecy, the reactive firm may have to purchase the innovative device and engage in reverse engineering. In the case of an innovation based on proprietary knowledge protected by patents, the reactive firm may research and develop ways to bypass the patent. One of the most well-known recent cases of this was Kodak's attempt to develop a camera with self developing film as Polaroid had years previously.

In our study, a window manufacturing firm provides a more typical example of the level at which this TDA is carried out in New Brunswick. In this example the firm's sales force reported that heritage style windows were gaining considerable market potential in the U.S. Manufacturers there were trying to produce a window that replicated the look of the leaded window of the 18th and 19th centuries. An examination of samples of the product led the product development manager in the New Brunswick firm to several conclusions about the direction it should take in its development efforts. The American windows were composites of small single glass panes with wood dividing strips between. They lacked strength and insulation properties. The firm decided that the product quality on which its marketing strategy had hitherto been based could not be maintained by efforts in this direction. This defensive R&D did not require an elaborate laboratory or an extensive testing programme. But it did require knowledgeable skilled professionals whose primary responsibility was product and process development. These personnel used their understanding of underlying principles to set the stage for the proactive R&D that followed. The New Brunswick Firm's response was a product with some of the look of the heritage style window incorporated into a design which used large panes of glass in sealed units thus preserving strength and insulation.

5.4.2 Proactive and Reactive Tinkering

Some firms adopt a proactive stance toward Tinkering. They experiment with existing machinery, devices, or processes to get them to work better even when it is already running normally. The proactive firm looks for opportunities to improve the way things run by adjustments and modifications to equipment. One such example among the firms subject to detailed field study was a metal fabricator that adopted a strategy of parsimony by buying second-hand machinery and then tinkering with it through modifications to get it run at an acceptable standard. In this case the proactive tinkering involved the search for opportunities for realizing cost savings in equipment purchases.

All firms also tinker reactively. They react to crisis. They tinker with equipment that suddenly breaks down during a production run or with new machinery that does not run quite as it should when it is first installed. One such example was the case of a metal fabricator who encountered difficulties with the protective coating it applied to wire. This firm had purchased equipment for applying the coating and the chemical itself from an American supplier. The supplier also provided technical support. Still, the manufacturer found that the process did not yield consistent results. On some production runs the coating flaked off. Without understanding fully what accounted for the inconsistent results in their particular plant, the production personnel altered many of the variables (e.g., baking time) in a trial and error process that eventually produced the consistent results required after over a month of Tinkering. Firms adopting a predominantly reactive stance to technology management treat such crisis occasions as the only occasions for tinkering and take few efforts to forestall such occasions.

5.4.3 Proactive & Reactive Monitoring

Firms adopting a proactive stance toward technology Monitoring seek information on new technologies in the environment. They send personnel to trade shows to survey new products. They send technicians to seminars and workshops. They send personnel to visit plants of competitors or to contact equipment suppliers regularly. They attempt to anticipate new technologies as opportunities and threats to their business.

Firms adopting a reactive stance allow information about new technologies to intrude on them in a haphazard fashion. One good set of examples from our research was in the fish-packing industry. One firm proactively sent a technical person to seminars and industry meetings which dealt with developing processing standards and techniques. One of these meetings was an information session attended by government inspectors. In this situation the development of best practice was clearly being monitored. This allowed this firm to anticipate and plan for new equipment to meet these standards. Other firms learned of the new standards reactively only when these same govnernment officials informed them during their regular inspections.

5.5 Principle Players and TEDD-NETs

There are three types of players in the TEDD-NET. They are the Firm, the Province, and other Public and Private sector players. These types of players will have varying degrees to which they participate in a given TEDD-NET. It is extremely rare for a TEDD-NET to be totally contained within a player. A case can be made that telephone technology was monopolized to this extent at certain times in its development, but this would be an extraordinary case. Typically there are many players in each aspect of the TEDD-NET although some players may be comprehensive enough in their approach to participate fully in all dimensions.

The assumption in this discussion is that government is typically involved in all aspects of TEDD-NETs. Government may be more or less conscious of these interrelationships. It may not realize the interconnections between network components. To be most effective the Province should be aware of TEDD-NETs and how they contribute to development. The best approach would be for government to identify specific TEDD-NETs to see whether the system can be enhanced. There are practical limits on the potentially infinite number of networks so identified.

The external players in the TEDD-NET do not necessarily act with unity. Individual players may be involved in one or other aspects of the TEDD-NET. They need not be organized with respect to the entire Network but rather these players can contribute to the field of relevant technologies. Coherence is created by Firms and Government. In addition, we have seen how suppliers and consultants can systematize and integrate components of technology networks.

5.5.1 Three Firm Types

In considering our recommendations we have to appreciate the differences in technology strategy among firms. Different tactics are appropriate to increase the technological effectiveness of these different types of firms. The three types which we identify are The Comprehensive Networker, The Engaged Observer, and the Isolate.

In developing policies to increase technological effectiveness in the New Brunswick manufacturing sector as a whole, it is important to identify which firms are the target of specific initiatives. We have identifed three types of firms. Each represents a different approach toward technology issues, and each represents a different degree of technological effectiveness. Each also represents a different proportion of New Brunswick manufacturing firms, the first being the least numerous and the last being the most numerous.

5.5.1.1 The Comprehensive Networker

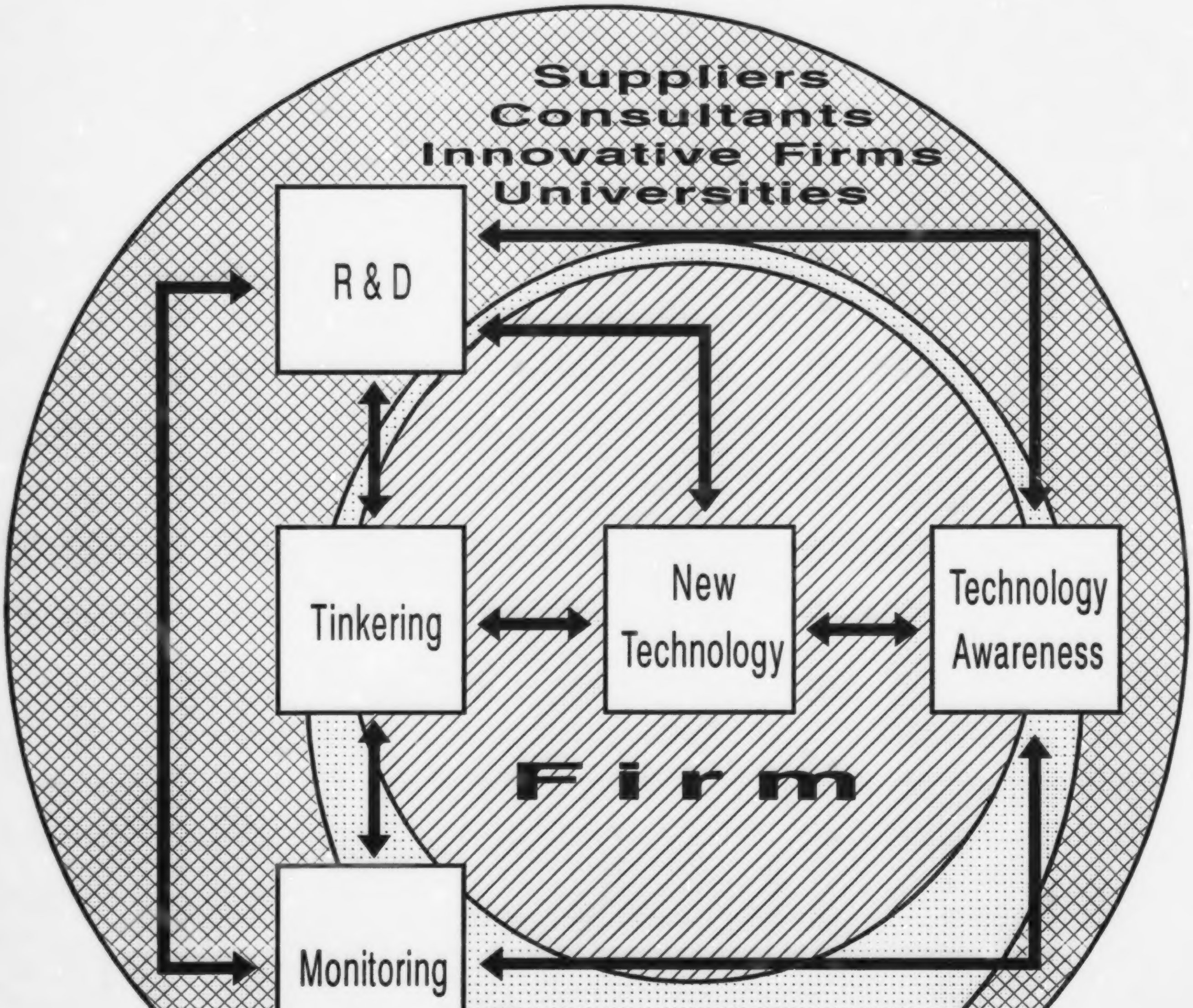
Figure 7 on page 95 shows the relationship between the Comprehensive Networker and the other TEDD-NET players. The ideal lead firm is involved in all aspects of the system. This type of firm has an R&D profile and dynamically interacts with New Technologies.

The Networker is the ideal firm. It engages in all three TDA's. It takes a proactive stance in monitoring its technological environment and is proactive in its tinkering with its manufacturing processes and its products. The networker also maintains some R&D capacity, choosing between a proactive and reactive stance toward this activity according to its resources, its interests, and its industry. It is important to emphasize that the Networker classification refers to a firm's approach to TEDD-NETs, not to types of technology. Comprehensive Networkers can be in a low or high tech industry. The type of technology will have consequences for its style of operation. In a high-tech industry such a firm is usually forced by circumstances to adopt a proactive R&D stance, but in other industries the ideal firm may choose a more reactive stance in its R&D.

In addition to devoting resources to all three TDA's, the ideal Comprehensive Networker adopts a technology strategy that performs all three in an integrated way which integrates its TDA's with those of other players in its TEDD-NET. It does not depend only on itself to perform these activities. It takes advantage of, and interacts with, the other players in the TEDD-NET of which it is a part. For example, it is aware of government research in its technology and draws upon the results of that research for its own purposes. Figure 7 on page 95 shows the relationship between the Comprehensive Networker and the other players.

This ideal firm is a lead firm in two senses. First, it sets an example of effective technological strategy that may influence the management practices of other firms. Second, it often leads its industry technologically by introducing new product or process technologies to New Brunswick by being the first to import them or by developing them here for the first time.

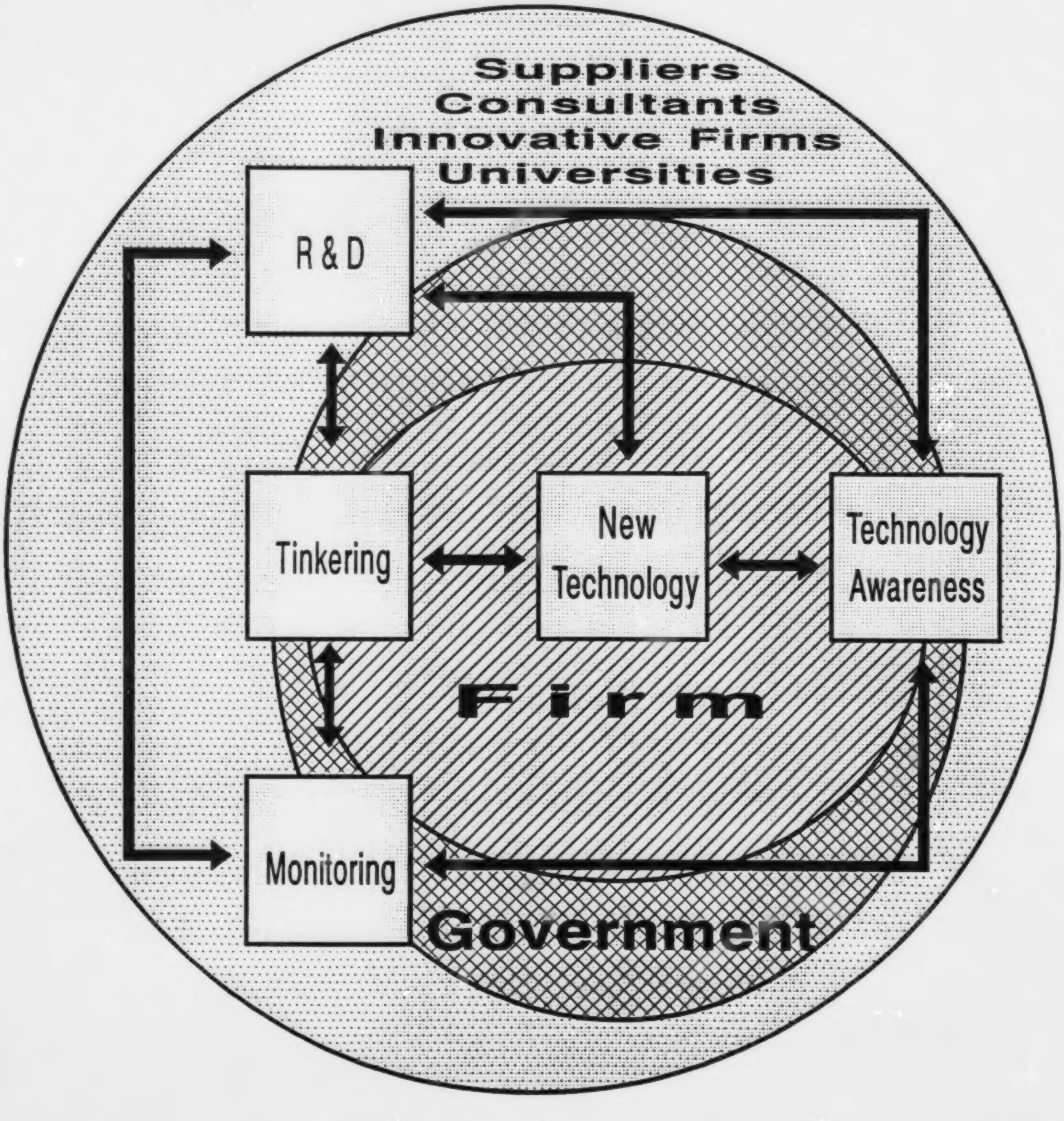
Figure 7
Firm with Comprehensive Networking Strategy


Suppliers
Consultants
Innovative Firms
Universities
R & D
Tinkering
New Technology
Technology Awareness
Firm
Monitoring
Government

5.5.1.2 The Engaged Observer

The Engaged Observer is a firm with an appreciation of the importance of technology to competitiveness. It proactively monitors its technological environment for new technological possibilities often by active participation in industry and professional associations, by cultivating contacts with competitors, government agencies and research organizations, as well as by following trade literature. It explores the possibilities that it can through proactive tinkering, and making use of the technical competences and interests of its shop floor personnel, production support staff, and other operations personnel. It is an apt follower of the accomplishments of lead firms in New Brunswick and even outside New Brunswick. Its interactions with other players in the TEDD-Net of which it is a part are portrayed in Figure 8 on page 99. A policy goal should be to move Isolates to Engaged Observers.

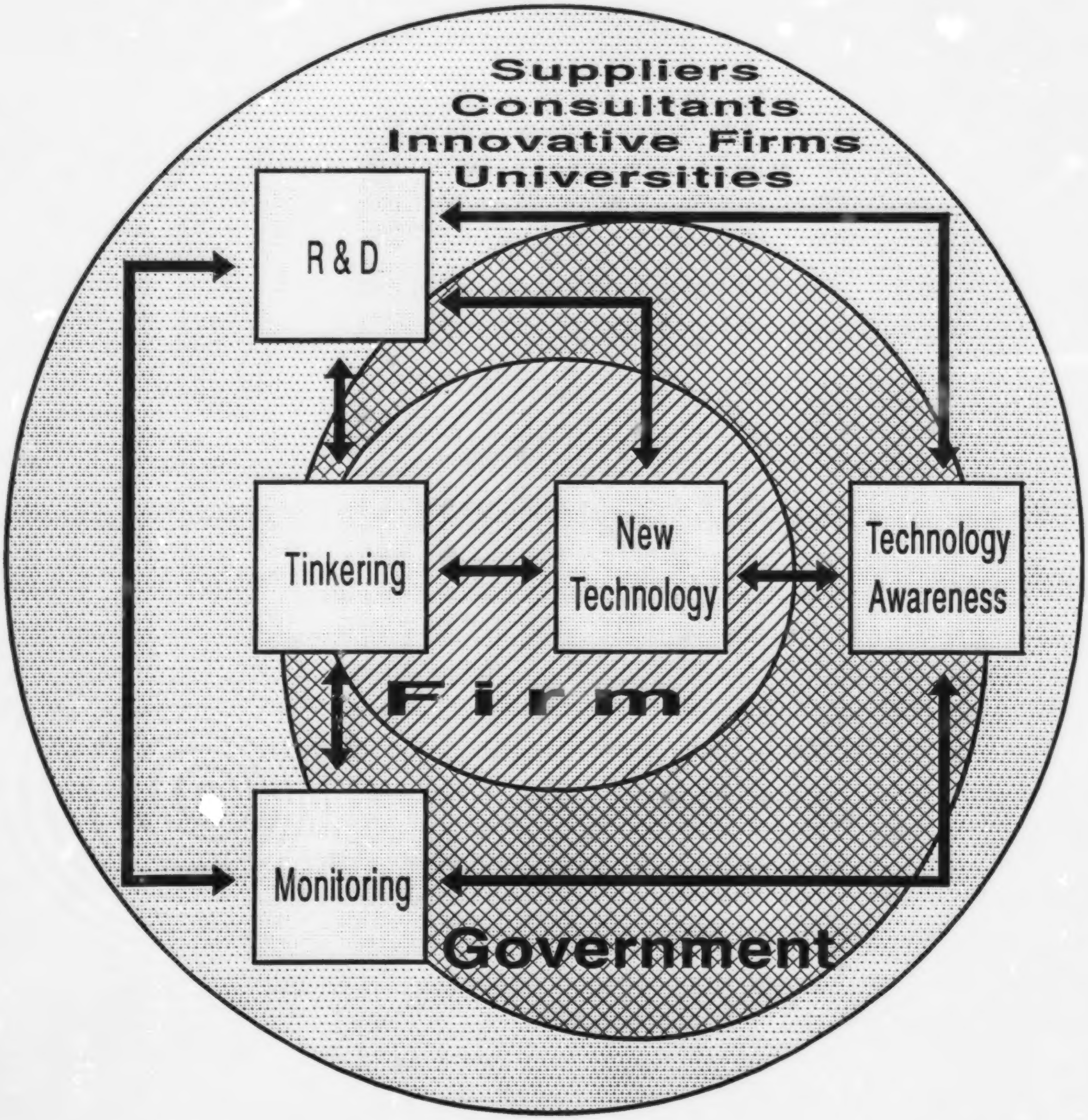
Figure 8
Engaged Observer Firm


Suppliers
Consultants
Innovative Firms
Universities
R & D
Tinkering
New Technology
Technology Awareness
Firm
Monitoring
Government

5.5.1.3 The Isolate

The Isolate, portrayed in Figure 9 on page 97, stands in contrast to the preceding types by virtue of its insular nature. It is reactive in its monitoring activity so that it is less aware than the first two of both the technological possibilities and the roles of the other players in its TEDD-NET. It also tends to be reactive in its tinkering, addressing technical issues on an ad hoc basis as problems and crises arise. Technologically its outlook is short-term, often because management's attention is absorbed with pressing problems in other operational areas. Many small firms are Isolates either due to a lack of resources or to a lack of interest in technology, or to the nature of their industry. If one were to sort each New Brunswick manufacturing firms into one of these three types (or stereotypes), this last type would easily be the most numerous.

Figure 9
Isolate Firm


Suppliers
Consultants
Innovative Firms
Universities
R & D
Tinkering
New Technology
Technology Awareness
Firm
Monitoring
Government

5.6 Recommendations for Technology Effectiveness

This section outlines recommendations for government action to increase technology effectiveness in New Brunswick. These recommendations include general policy directions as well as specific steps toward the goal of technology effectiveness.

Recommendation 1: Broaden Visions of Technology and Technological Effectiveness

Although all manufacturing firms confront technological issues in carrying on their business, awareness of the means for dealing with those issues and the possibilities for effective action differ greatly from firm to firm. In part this is a function of differing concepts of technology. To some, "technology" was synonymous with 'high tech'. It had to do with the application of computers and robotics to manufacturing. To manage technology was to engage in R&D. For a firm without the resources to establish a formally organized R&D facility or for a firm in an industry characterized by mature, stable, relatively unsophisticated technology to hold such a definition of "technology" is likely to lead to its downgrading the true importance of its own technology. Technology development activity would appear to it to be activity undertaken in other industries by other firms. Such firms may well miss the importance and the potential of both Monitoring and Tinkering as TDA's and thereby adopt a reactive attitude toward both.

Government 's first step in fostering technological effectiveness across the spectrum of manufacturing industries is one of consciousness raising in all quarters concerning the importance of technological issues. It is to promote the possibility of increasing technological effectiveness not only through radical technological innovation resulting from R&D in high-tech industries but also by continuous incremental innovation from proactive tinkering guided by proactive monitoring in low-tech industries. Firms must be aware of their technological environment.

Recommendation 2: Adjust Technology Policy to Specific Types of Firms

We have identified three types of firms in New Brunswick manufacturing with regard to their technological stance and their effectiveness. Policies designed to improve the effectiveness of one type may leave firms of the other type untouched. For example, policies designed to support and encourage R&D and thereby to make the Comprehensive Networkers more effective, probably will have little impact on the Engaged Observers and the Isolates, who do not perform R&D. These latter firms could become more technologically effective through support for the TDA's in which they do engage -- namely, Tinkering and Monitoring. To increase technological effectiveness across the spectrum of New Brunswick manufacturing firms, including the majority of firms we classify as Isolates, each type of firm should be targeted by Government in its technology support policy.

Recommendation 3: Target Engaged Observers and Isolates

Most firms in New Brunswick are either Isolates or Engaged Observers. Government Policy should not exclude this majority of firms. Government may be called on to assist and encourage leading R&D firms but this should not be the focus of technology policy. It is not realistic to see widespread propagation of Comprehensive Networkers with aggressive R&D postures as the means to increasing technology effectiveness in the manufactuiring sector as a whole. Government cannot not taken care of technology by the cultivation of high technology enterprise. R&D firms can be critical and high profile, but they will not be common in New Brunswick. It is important that technology effectiveness is taken as a priority for traditional and small scale enterprise. In this respect, the province, in its general policy direction, should emphasize services which will assist Comprehensive Networkers, Engaged Observers, and Isolates.

Recommendation 4: Provide and Highlight Tinkering Capacity

This enhances effectiveness directly and, indirectly, can be a "foot in the door" for a more comprehensive strategy. This is especially important in trying to move Isolates to an Engaged Observer approach. Isolates stumble into problems and it is then that they are receptive to outside input. Our research showed that firms identified RPC as a place where they could go for assistance. The government should use its profile to enhance technology effectiveness and to import into the firm a more proactive approach. An additional payoff of government being directly involved with tinkering is the information this provides on the technological problems of firms.

The importance of on site contact with firms is demonstrated by the responses firms gave us to our queries about the channels they would find useful in providing information and expertise in relation to product and process technologies. The highest values were for on site consultants who were favoured by 53.7% of firms for product technology (see Table 32 on page 104) and in 58.5% of firms in relation to process technology (see Table 33 on page 105). Also interesting here is that smaller firms valued this direct contact more highly than larger firms. For example, in Table 32, 64.7% of small firms and 63.6% of medium firms stated that consultants travelling to them would be useful as compared to 30.8% for large firms.

Table 32 Useful Product Technology Channels

	FIRM SIZE			Total
	Small	Medium	Large	
Useful Technology Channels				
Technology Information Centres	7	4	4	15
	46.7%	26.7%	26.7%	100.0%
	41.2%	36.4%	30.8%	36.6%
Consultants with fax	10	7	4	21
	47.6%	33.3%	19.0%	100.0%
	58.8%	63.6%	30.8%	51.2%
Consultants that travel to you	11	7	4	22
	50.0%	31.8%	18.2%	100.0%
	64.7%	63.6%	30.8%	53.7%
Computer links	4	4	2	10
	40.0%	40.0%	20.0%	100.0%
	23.5%	36.4%	15.4%	24.4%
Computer link at information centre	3	3	2	8
	37.5%	37.5%	25.0%	100.0%
	17.6%	27.3%	15.4%	19.5%
None of these ideas useful	5	2	7	14
	35.7%	14.3%	50.0%	100.0%
	29.4%	18.2%	53.8%	34.1%
Total	17	11	13	41
	100.0%	100.0%	100.0%	100.0%
	41.5%	26.8%	31.7%	100.0%

Table 33 Useful Process Technology Channels

	FIRM SIZE			Total
	Small	Medium	Large	
Useful Technology Channels				
Technology Information Centres	9	6	4	19
	47.4%	31.6%	21.1%	100.0%
	60.0%	54.5%	26.7%	46.3%
Consultants with fax	8	4	5	17
	47.1%	23.5%	29.4%	100.0%
	53.3%	36.4%	33.3%	41.5%
Consultants that travel to you	9	7	8	24
	37.5%	29.2%	33.3%	100.0%
	60.0%	63.6%	53.3%	58.5%
Computer links	3	2	2	7
	42.9%	28.6%	28.6%	100.0%
	20.0%	18.2%	13.3%	17.1%
Computer link at information centre	4	1	2	7
	57.1%	14.3%	28.6%	100.0%
	26.7%	9.1%	13.3%	17.1%
None of these ideas useful	4	2	6	12
	33.3%	16.7%	50.0%	100.0%
	26.7%	18.2%	40.0%	29.3%
Total	15	11	15	41
	100.0%	100.0%	100.0%	100.0%
	36.6%	26.8%	36.6%	100.0%

Recommendation 5: Provide Infrastructure to Support Monitoring

Monitoring leads to the awareness of specific technologies appropriate to one's industry. It also leads to an awareness of TEDD-NETs. Proactive monitoring supports R&D, and proactive tinkering, and is the basis of an effective technology strategy. Programmes which provide financial support to firms to attend trade shows for example, facilitate monitoring in some firms. However, a unified technology information policy would encourage and support monitoring in all types of firms including Isolates and Engaged Observers firms with very limited resources.

Such a system has two elements: the mechanism for information collection, and the mechanism for its delivery. Information collection can to a certain extent be carried out by government. However, the intelligence which has to be gathered is so varied and contextual that government cannot hope to be exhaustive.

Recommendation 6: Provide Incentives for Information Sharing

Following from the above, Comprehensive Networkers and Engaged Observers often will have the best information. On the delivery side, government should provide incentives for information sharing for these types of firms. The precise way this could be done could vary. A strong policy could tie financial and technical assistance with information dissemination commitments.

Recommendation 7: Emphasize Personal Contact as Opposed to Hardware based Information Systems for Clients

As was clear from Tables 32 and 33 on pages 104 and 105 personal contact appears critical for effective communication with firms. The preferred form of contact was consultants which travel to the firm, or who directly contact firms through fax. Personal contact at information centres was also seen as useful (30.6% for product channels and 46.3% for process channels). These forms of direct personal contact were clearly preferred to either direct computer links (24.4% for product and 17.1% for process) or computer links at information centres (19.5% for product and 17.1% for process). Computerized information systems are powerful tools, but as of yet they should remain the tools of the personnel in the information system.

Recommendation 8: Shift Isolates to Engaged Observers

So far the recommendations have been directed toward how to take advantage of existing industrial and technological patterns in the province. We have stated that it is not realistic to have all, or even a large number of firms in New Brunswick, as Comprehensive Networkers. It is, however, realistic that technological Isolates be moved over to an Engaged Observer approach. It should be a major policy goal of government to encourage awareness among firms and to have them monitor what is relevant to them. Network Monitoring in many cases is most effectively done by the firms affected. Technological isolation is a major problem in the province. As we have seen time and again New Brunswick manufacturing is not tied into TEDD-NETs. Firms tinker with their own local problems in isolation. For example, see Tables 17 and 18 on pages 53 and 54 where firms state categorically that technology development was done totally or largely independently of others. The least technologically effective firms are the Isolates. If such firms can be brought to adopt a proactive stance to monitoring and tinkering -- i.e., if they become Engaged Observers -- the manufacturing sector as a whole becomes more technologically effective. New Brunswick manufacturing needs to take advantage of the technology which is available in an increasingly global economy.

Recommendation 9: Identify TEDD-NETs

Although it is not possible to be exhaustive, the Province should identify TEDD-NETs. This is especially the case in orphan technologies where there are not large players in New Brunswick. TEDD-NETs may cut across industry sectors (coatings, computerization), and it is here that government can supplement industry groups, which by their nature are industry specific. The province must be aware of its TEDD-NET portfolio.

Recommendation 10: Technology Management

Managers in technologically isolated firms often lack full TEDD-NET awareness of all the players and the signification interactions among them. As government identifies particular TEDD-NETs it deems critical to support, it should organize forums which draw managers together from the relevant firms. Such forums could be centered on the discussion of particular technical problems in a technology at the center of a TEDD-NET. They could focus on industry problems or product-market problems in the case of TEDD-NETs whose member firms come predominantly from one industry. The forums could be print media forums. The forums could be organized and structured through industry associations. However, the important objective of these forums is generally to enhance management awareness of other players in the TEDD-NET and begin networking with those other players. More specifically it is to enhance the awareness of management from firms that are technologically isolated and to draw them into the first steps of more active participation in their TEDD-NET. Many of these will be small and medium sized firms.

An example of a forum cultivating TEDD-NET awareness is the seminars and workshops the Maritime Ranger School held for portable sawmill technology. The stated objective of these sessions was the transfer of information and expertise concerning technical problems associated with portable sawmill technology at the centre of this TEDD-NET. A further benefit claimed by the owners and managers attending was their increased awareness from the workshop of other players in this TEDD-NET-- i.e., other Maritime portable sawmill operators, foreign equipment suppliers, government wood technology research agencies in Central Canada, etc. The firms involved in these forums were all small and would be characterized by our classification as Isolates who were beginning to emerge as Engaged Observers.

Recommendation 11: Invest in Formal Education for the Long Term

Continued investment in formal technical education is necessary in order to achieve two objectives: (i) a growing pool of specific critical technical skills in the workforce and (ii) a general aptitude for and proactive interest in Tinkering activity on the shop floor. This study documents the upward drift in educational requirements in the manufacturing workforce and management's perception that acquiring skilled personnel has been a difficulty in implementing technological innovation. So far that innovation has been predominantly incremental, and the increased workforce skill requirements have largely been met by retraining existing workers within the firm. Achieving the first objective of formal technical education is critical if more radical technological innovation is to be accommodated within New Brunswick manufacturing. The lack of personnel with many critical skills will act as a constraint on this type of innovation. The second objective recognizes the likelihood that many technologically mature industries will continue to play a major role in the province's economy. To be competitive firms in these industries must cultivate technological innovation that will be predominantly incremental, brought about in large part by proactive Tinkering by the workforce on the shop floor. A general aptitude for solving technical problems as well as an interest and pride in tinkering with devices is required in the workforce in order to support this critical TDA. Educational institutions training techncial specialists and professionals should have the inculcation of this general aptitude and this technologically proactive attitude as one of their explicit objectives. It is not sufficient for them to address objective (1) alone.

APPENDIX 1

CEO INTERVIEW SCHEDULE

The CEO interview was an in person interview for which the interviewer used the following form (or its French translation for interviews conducted with those choosing French as their language of preference). Interviewers recorded responses on this form.

CEO INTERVIEW

PRELIMINARY INFORMATION

(INTERVIEWER FILLS THESE BEFORE INTERVIEW)

NAME OF FIRM ____________________

DATE OF INTERVIEW ____________________

TIME OF INTERVIEW ____________________

INTERVIEWER NAME ____________________

INTERVIEWEE'S NAME ____________________

INTERVIEWEE'S TITLE OR POSITION ____________________

IS THE INTERVIEWEE CEO OR COO? YES NO (CIRCLE ONE)

AMBIGUITY ABOUT DEFINITION OR IDENTIFICATION OF SUBJECT FIRM?

NO

YES IF YES,
COMMENTS

CONFIRM FIRM'S INDUSTRY AS ____________________ (TYPE)

CEO Interview PAGE 2

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CEO INTERVIEW PREAMBLE

1. TAPE RECORDER Issue

2. Review STRUCTURE of Study:
   CEO Interview; 2 Mailback Questionnaires -- one on Product Innovation and one on Process Innovation

3. GENERAL INTEREST of Study: - in how firms manage NEW and EXISTING TECHNOLOGY for both PRODUCT and PROCESS change
   -This interview is to get an OVERVIEW of the firm.
   -We need to find out FACTS about your firm that are important to understanding WHY and HOW you manage product and process CHANGES in the way you do.

4. PURPOSE of the Study:

   A. ACADEMIC RESEARCH, and B. a REPORT; we have been commissioned by the New Brunswick Department of Commerce and Technology to gather information which will help the Department provide effective support to its clients.

   REPORTS AIM: To increase the Commerce and Technology Departments' understanding of its clients' needs with respect to adopting NEW TECHNOLOGY and managing EXISTING TECHNOLOGY

   -The Department has a variety of clients --small firms and large firms, a variety of industry sectors, and so on.

   -Each type of client has different needs. For example, small firms have different problems in locating technological support than do larger ones. They search for new technologies from different sources than do larger firms. They make decisions about product and process changes in different ways.

   The Report will provide a means of matching firms with SIMILAR NEEDS who may be approached and aided in SIMILAR WAYS.

CEO Interview PAGE 3

5. The STRUCTURED nature of the Interview:

The interview will be fairly structured with lots of yes-no questions and questions requiring numbers. I would like to go through the interview with you first, and if, at the end, there are other things you would like to talk about, you can do it then.

6. Small Firm and Type of Industry REASSURANCE (as necessary)

7. CONFIDENTIALITY:

We treat the information we receive from this interview and from the questionnaires as confidential between the Technology Diffusion Project and the firm. We release data only in a form that preserves anonymity of each participating firm.

8. Review TIME REQUIREMENTS: 1 to 1 1/2 hours

9. Review AGENDA: Topics to be discussed

1. A bit of your personal background
2. A few details concerning Your Marketing and Production
3. Organization and Management Structure
4. Your industry contacts
5. Your experience with provincial agencies supporting technological development in the private sector

At the outset let me understand exactly what is included in the firm we'll be discussing in this interview.

INTERVIEWER READS BACK WHAT HE UNDERSTANDS THE FIRM TO INCLUDE AND CLARIFIES ANY AMBIGUITIES

COMMENTS

WORK HISTORY

1. In what year did the firm start up operations?________ date

2. How many years have you been with the firm?________ years

3. How many years have you been in your present position with the firm?

________ years

4. What positions have you held in the firm before this one? How long were you in each one? Please begin with the most recent.

[INTERVIEWERS PROBE FOR POSITIONS IN DIFFERENT AREAS OF THE FIRM: EG. PRODUCTION, FINANCE, SALES, PURCHASING]

	POSITION	# OF YEARS
1. (most recent)	________	________
2. (next most recent)	________	________
3.	________	________
4.	________	________
5.	________	________

5. Where did you live JUST BEFORE joining this firm?
(CITY AND PROVINCE/STATE)

6. Did you work elsewhere in the ____________________________ industry before you joined this firm?

IF NO, WRITE 0 BELOW
IF YES, ASK: **How many years was that? _______** years

7. Did you work in OTHER manufacturing or processing industries [before that] ?

IF NO, WRITE 0 BELOW
IF YES, ASK: **How many years was that? _______** years

SALES AND MARKETS

["Now a few questions about the firm's sales and its markets"]
HAND CARD I to interviewee

8. Here is a list of geographical markets. Approximately what percentage of the firm's total sales go to each of them?

a) New Brunswick ______%
b) Atlantic provinces outside NB ______%
c) Canada outside the Atlantic provinces ______%
d) US ______%
e) Other (specify) ______________________ ______%
______________________ ______%

ALLOW INTERVIEWEE TO COLLAPSE (a) and (b) IF HE/SHE CANNOT DISTINGUISH

IF THERE IS ONLY ONE MARKET AREA SKIP TO QUESTION 10. ⟶

9. Using the same list, in which market are the firm's sales growing at the fastest rate?
(Check the appropriate one(s))

a) New Brunswick ______
b) Atlantic provinces outside NB ______
c) Canada outside the Atlantic provinces ______
d) US ______
e) Other (specify) ______________________
____

10. Does your firm use formally organized market research?

PROMPT: FORMALLY ORGANIZED MARKET RESEARCH = Systematic efforts to gather information about customers. Someone is formally responsible for these efforts.

YES

NO IF NO, SKIP TO QUESTION 12.

11. Who does the market research? (check all appropriate)

a) the firm's own personnel ____

b) outside consultants ____

c) other (specify)________________________________

→ **12. Does the firm have its own sales force?**

PROMPT: SALES FORCE = Those people who actively contact potential customers and get orders.

YES

NO IF NO, SKIP TO QUESTION 14.

13. What percentage of sales are handled by its own force? ______________%

→ **14. For what percentage of its sales does the firm deal directly with end-users of its products?**

________________________%

15. What were your firm's GROSS sales revenues for 1989?

$______________

PROMPT:
REMIND INTERVIEWEE OF CONFIDENTIALITY COMMITMENT
EXPLAIN USE AS A MEASURE FOR SIZE
ASK FOR APPROXIMATE OR BALLPARK FIGURES IF RESISTANCE

INDICATE IF BALLPARK FIGURE – BALLPARK FIGURE? YES NO
RECORD COMMENTS ON SIZE OF BALLPARK

IF THERE IS STILL RESISTANCE, ASK INTERVIEWEE:

Into which of the following ranges does your 1989 gross sales figure fall?

a) under $500,000	___
b) $500,000 - $1,000,000	___
c) $1,000,000 - $2,000,000	___
d) $2,000,000 - $5,000,000	___
e) $5,000,000 - $10,000,000	___
f) $10,000,000 - $20,000,000	___
g) $20,000,000 - $50,000,000	___
h) $50,000,000 and above	___

RECORD COMMENTS IF 1989 WAS AN UNUSUAL OR ABNORMAL YEAR

ASK FOR 1988 FIGURES IF INTERVIEWEE COMMENTS THAT 1989 WAS UNUSUAL OR ABNORMAL

1988 GROSS SALES: $ ________

OWNERSHIP AND CONTROL

["We now have a few questions about the firm's ownership and control"]

16. How many managers in your firm INCLUDING YOURSELF currently own shares in it? PROMPT: MANAGERS = All those with responsibilities for supervising others or those who participate in making major decisions.

__________ managers

17. Is the firm controlled by another firm?

YES

NO - IF NO, SKIP NEXT PAGE AND GO TO QUESTION 22. ——————— >

18. Is your firm a wholly owned subsidiary?

YES

NO

19. Where is your controlling parent's headquarters located?

____________________ SPECIFY CITY & PROVINCE/STATE

IF RESISTANCE, ASK INTERVIEWEE TO LOCATE PARENT IN:

a) New Brunswick
b) Atlantic Region outside NB
c) Canada outside Atlantic Region
d) Outside Canada

20. Does the parent own any other subsidiaries in the same or in a related line of business to your firm?

YES

NO

HAND CARD II to interviewee.

21. Here is a list of some types of decisions firms make. How much influence does headquarters management exercise over your decision making in each of these areas?

	NO INFLU-ENCE	SOME INFLU-ENCE	MAJOR INFLU-ENCE	TOTAL INFLU-ENCE
a) new product introduction	____	____	____	____
b) new production processes	____	____	____	____
c) production equipment replacement	____	____	____	____
d) supplier selection	____	____	____	____
e) target market selection & development	____	____	____	____
f) research & development strategy	____	____	____	____

WORKFORCE AND SEASONALITY

["We now have some questions on your workforce"]

22. What was the maximum TOTAL employment in the firm in 1989?

_______ employees

23. Is the workforce unionized in your production or manufacturing units?

YES

→ NO - IF NO, GO TO QUESTION 25.

24. What percentage of production line and support workers are unionized?

_______ %

→ **25. What was the MAXIMUM employment in the firm's PRODUCTION facilities or PRODUCTION departments in 1989?**

_______ employees

26. What was the MINIMUM employment in the firm's PRODUCTION facilities or PRODUCTION departments in 1989?

_______ employees

NOTE: IF MINIMUM AND MAXIMUM EMPLOYMENT ARE THE SAME, GO TO QUESTION 29. →

27. Is some of the difference due to seasonality?

YES

NO IF NO, SKIP TO QUESTION 29. →

28. What percentage of the difference was due to seasonality?

_______ %

ORGANIZATION STRUCTURE AND POLICIES

29. What levels of management are there above the PRODUCTION LINE WORKER?

______________	RECORD NAMES OF MANAGEMENT POSITIONS
______________	(FOREMAN, PLANT SUPERVISOR, ETC.)
______________	BE SURE INTERVIEWEE INCLUDES HIMSELF WHERE APPROPRIATE.
______________	

IF THE INTERVIEWEE RAISES THE QUESTION OF LEAD HANDS, RECORD THE REMARKS

COUNT AND RECORD THE LEVELS OF MANAGEMENT BETWEEN THE LINE WORKER AND THE CE0

_____ Levels

30. Strategic decisions are decisions that set or change the long term direction and character of the firm. These would include decisions about launching new products, entering new markets, acquisitions, major plant expansions, organizational restructuring, financing by taking on new investors and so on.

Which managers participate in making strategic decisions about the firm's long range direction. Please identify them by POSITION and AREA OF RESPONSIBILITY. (Finance, Marketing etc.,)

a.______________

b.______________

c.______________

d.______________

e.______________

HAND CARD III to interviewee

31. Here is a list of specifically TECHNICAL functions and activities found in some firms. Are there functions on the list for which a particular person or group is formally assigned responsibility? Which ones?

	YES	PRIMARY JOB RESPONSIBILITY	
		Yes	No
a) Research and Development	___	___	___
b) Product Development	___	___	___
c) Production Engineering	___	___	___
d) Quality Control	___	___	___
e) Product Testing	___	___	___
f) Machinery Maintenance	___	___	___
g) Process & Equipment Development	___	___	___
h) Information Systems	___	___	___
i) Other specifically technical or engineering units (specify) ______________	___	___	___

FOR EACH FUNCTION WHICH HAS RECEIVED A YES ANSWER

32. Is this function the MAJOR OR PRIMARY job responsibility of the person or people assigned to it?

INTERVIEWER USES GRID ABOVE TO RECORD ANSWER ——————————————

RECORD A "YES" FOR EACH FUNCTION FOR WHICH THERE IS AT LEAST ONE PERSON WHOSE PRIMARY JOB RESPONSIBILITIES ARE THAT FUNCTION?

33. How many employees are there whose major responsibility is to those groups?

____ employees

IN CASE OF DIFFICULTY WITH ADDING UP TOTAL EMPLOYEES,
LEAD INTERVIEWEE THRU GROUP BY GROUP ABOVE

PROFILE OF MANAGEMENT & TECHNICAL PERSONNEL

["Now I'd like to ask you about various categories of current employees. I shall be asking for numbers in each category. INCLUDE YOURSELF in your count where you fall into one of the categories."]

34. ["First"] What is the total CURRENT employment?________ employees

35. How many managers are there above the rank of foreman? PROMPT: MANAGERS = All those with responsibilities for supervising others or those who participate in making decidions.

________ managers

36. How many foremen are there?_______ foremen

["Next, with respect to educational qualifications"]

37. How many managers have university degrees?________ managers

IF 0 MANAGERS HAVE DEGREES, SKIP TO QUESTION 40. ⟶

38. How many managers have engineering degrees in particular?________

39. How many have MBAs?________ MBAs

40. We are interested in comparing the respective roles of experience and formal education in the background of senior management. We would be interested in the highest level of education YOU have completed?

a) elementary school or some high school	____
b) high school diploma	____
c) business, technical or trades training (e.g., secretarial, trade school)	____
d) Community College or Institute of Technology	____
e) Some university (no degree)	____
f) University Degree	____

SPECIFY BY ASKING:

→ **41. "What university degrees do you hold? (B.Sc. etc.)"**

____

____

42. We are also interested in any technical specialists involved in product development, in the production process and in the maintenance of production facilities and in engineering specialties.

Do you have any engineers?

YES

NO IF NO, SKIP NEXT PAGE AND GO TO QUESTION 49. →

[" I have a list of engineering specialties. Out of all your employees,...]

43. How many industrial engineers are there? ___ industrial engineers

44. How many mechanical engineers? ___ mechanical engineers

45. How many electrial engineers? ___ electrical engineers

46. How many chemical engineers? ___ chemical engineers

47. How many civil engineers? ___ civil engineers

48. Are there any engineering specialties I have missed?

SPECIFY TYPE OF ENGINEER AND NUMBER IN FIRM

TYPE	NUMBER
a) ____________________	___
b) ____________________	___

49. Do you have other technical specialists involved in either product development or the production unit.

YES

NO IF NO, SKIP TO QUESTION 51.

50. List the type of technical specialists and how many of each you have.

	TYPE	NUMBER
a)	________________	_____
b)	________________	_____
c)	________________	_____

→ **51. How many INFORMATION systems analysts or INFORMATION system designers are there?**

____ analysts/designers

52. How many computer programmers? ____ computer programmers

53. Again, INCLUDING YOURSELF, how many managers above the rank of foreman are currently members of trade or professional organizations?

______________ managers

54. How many managers above the rank of foreman have attended at least one trade show or convention or conference within the past year?

______________ managers

55. Is it accepted practice in your industry for managers or technical specialists from one firm to visit plants in others? (This could be for any of several reasons including: evaluating equipment from a common industrial supplier, consulting on common technical problems, concluding contractual arrangements of various kinds.)

YES

NO IF NO, GO TO QUESTION 57.

56. How many managers above the rank of foreman have visited at least one plant of another firm in the industry within the last 12 months?

_____ managers

INDUSTRY CONTACTS

57. Does your firm belong to any industry or trade associations?

YES

NO IF NO, SKIP TO QUESTION 61. →

58. Which industry or trade associations does the firm belong to?

1. ______________________________
2. ______________________________
3. ______________________________

HAND CARD IV to interviewee

["Here is a list of possible benefits and services industry or trade associations provide to their members."]

59. Which benefits or services does your firm get from belonging to its industry or trade associations?

INTERVIEWER READS EACH BENEFIT AND CHECKS YES IF BENEFIT PROVIDED

	YES	VERY IMPOR-TANT	IMPOR TANT	SOME IMPOR TANCE	NO IMPOR TANCE
a) product standards setting for the industry	__	____	____	____	____
b) joint efforts in relations with government	__	____	____	____	____
c) shared marketing information	__	____	____	____	____
d) joint marketing efforts	__	____	____	____	____
e) shared information on production technology	__	____	____	____	____
f) shared information on product technology	__	____	____	____	____
g) other (SPECIFY)					

____

____

HAND CARD V TO INTERVIEWEE

60. How important to your firm is each of the benefits that it does receive from industry associations?

INTERVIEWER READS EACH BENEFIT ON GRID ABOVE CHECKED WITH YES AND ASKS FOR IMPORTANCE

61. How many times in the last two years have other firms in the industry approached yours for information on either product or process technology in use in your firm?

______ times

62. How many suggestions for new products or product changes have customers made to the firm within the last 2 years?

______ suggestions

EXPENDITURES ON PROCESS AND PRODUCT DEVELOPMENT

63. Did you make any expenditures on Research & Development in your 1989 fiscal year?

YES

__________NO IF NO, GO TO QUESTION 66.

64. How much did you spend on R&D in fiscal 1989? $_______

ACCEPT A PERCENTAGE OF SALES FIGURE
IF INTERVIEWEE OFFERS ONE

_____% of 1989 sales

65. Did you formally budget for R&D expenditures for your 1989 fiscal year?

YES

NO

→ **66. Estimate how much the firm spent on manufacturing or production process improvements during that year?**

$_______ IF THE ANSWER IS 0, SKIP TO QUESTION 68. →

WHERE INTERVIEWEE DOES NOT GIVE AN ANSWER, RECORD ANY REACTIONS OR REMARKS

"I don't know"____

"too difficult to figure out"____

other (specify)____

67. Briefly list some of the process improvements you implemented in that year.

____

____

____

68. Estimate how much the firm actually spent on all activities connected with product development and introduction during that year.

$________

IN CASES WHERE INTERVIEWEE DOES NOT GIVE AN ANSWER, RECORD ANY REACTIONS OR REMARKS

"I don't know"____

"too difficult
to figure out"____

other (specify) ____

OUTSIDE SUPPORT FOR PRODUCT AND PROCESS DEVELOPMENT

HAND CARD VI to interviewee

["Here is a list of public sector agencies in New Brunswick that support product development and production process development."]

69. Have you heard of the services offered by any of these agencies?
(INTERVIEWER OFFERS LOCATIONS OF THESE AGENCIES IF ASKED)

	HEARD OF SERVICES		USED SERVICES	
	YES	NO	YES	NO
a) Research Productivity Council (RPC)	___	___	___	___
b) Manufacturing Technology Centres (MTCs)	___	___	___	___
c) CADMI Centres	___	___	___	___
d) Food Research Centre	___	___	___	___
e) Wood Science and Technology Centre	___	___	___	___
f) Science and Technology Information Service	___	___	___	___

70. For each agency you mentioned, have you used any of its services?

RECORD ANSWERS ON THE ABOVE GRID UNDER "USED SERVICES". -

71. Focusing first on PRODUCT CHANGE, what services could outside organizations provide that would best support PRODUCT development in your firm?

72. Now focusing on MANUFACTURING OR PRODUCTION PROCESS CHANGE, what services could outside organizations provide that would best support PROCESS development in your firm?

TECHNOLOGY AND INNOVATION POLICY

HAND CARD VII to interviewee

73. Here is a list of a few factors that can be important to a firm's success. They may remind you of others not on the list that are important to your firm. How important do you believe each of these or any other not on the list will be for your firm's success over the next ten years?

INTERVIEWER READS EACH FACTOR ALOUD AND PROMPTS INTERVIEWEE WITH POSSIBLE ANSWERS

	VERY Important	IMPORTANT	SOMEWHAT Important	NOT Important	DONT KNOW NOT SURE
a) Financing	___	___	___	___	___
b) Competition from Imports	___	___	___	___	___
c) Development of Export Markets	___	___	___	___	___
d) Sales Promotion	___	___	___	___	___
e) New Product Technology	___	___	___	___	___
f) New Process Technology	___	___	___	___	___
g) Labour Savings	___	___	___	___	___
h) Increase in Firm Size	___	___	___	___	___
i) Recruiting Skilled Personnel	___	___	___	___	___

j) Other (specify) ____

____

HAND CARD VIII to the interviewee

> **The following questions are used to study the firm's practices in various functional areas. Read each statement and circle the code that indicates whether you strongly agree, agree, disagree, or strongly disagree with it as it applies to your firm.**

INTERVIEWER REVIEWS THE CODES WITH THE INTERVIEWEE:

> "SA = STRONGLY AGREE; A = AGREE; D = DISAGREE;
> SD = STRONGLY DISAGREE.".

INTERVIEWER ALLOWS INTERVIEWEE TO COMPLETE CARD VII QUESTIONNAIRE

INTERVIEWER COLLECTS CARD VII QUESTIONNAIRE WHEN INTERVIEWEE IS FINISHED.

74. We have a tradition and reputation in our industry of attempting to be first to try out new methods and equipment.

75. We spend more than most firms in our industry on new product development.

76. In our industry it is wiser not to take risks with new manufacturing equipment before it has been proven out by other firms.

77. We are actively engaged in a campaign to recruit the best qualified marketing personnel available.

78. We are actively engaged in efforts to recruit the best qualified technical personnel available (engineering and production)

79. We usually make plant floor available for experimentation with new processing equipment.

80. Senior managers from our firm regularly spend time with customers assessing their needs and soliciting their ideas for product improvement.

COLLECT CARDS AND TAPE RECORDER

APPENDIX 2

PRODUCT QUESTIONNAIRE
AND
MANUFACTURING PROCESS QUESTIONNAIRE

The Product Questionnaire and the Manufacturing Process Questionnaire were each left with one appropriate respondent in each firm. Respondents filled in the questionnaires at their convenience and returned them by mail to the Technology Diffusion Project. French versions of the questionnaires were left with respondents who expressed a preference for French as the language of response.

Product Questionnaire starts at page 145 and the Manufacturing Process Questionnaire starts at page 157.

Product Questionnaire

Firm:

Name of Respondent:

Position of Respondent:

This questionnaire deals with product technologies. The focus is on change. The questionnaire asks about an individual product in your firm's product line. There are 2 sections:

Section 1 - Product Development
Section 2 - Product Technologies

You are asked to select one product that has been introduced to the firm's product line within the last ten years. This could be a totally new product or a modification of existing products. Throughout this questionnaire whenever you are asked to comment on the product or product change it refers to the product you choose now.

Should you have any questions about this survey please contact :

Peggy Wight, Research Associate
Technology Diffusion Project
Mount Allison University
Sackville, N.B, E0A 3C0.
telephone: (506) 364-2624 fax: (506) 364-2625

DATE:

PHONE BACK DATE:

Section 1 - Product Development

This section deals with how the product you chose was developed and introduced.

1. Name the product.

2. Briefly describe the product.

3. What was new or different about the product?

4. In what year did your firm first commit significant resources to developing the product?

19___

5. In what year did your firm put the product on the market?

19___

6. How different was the product from other products IN YOUR FIRM at the time of development? (check one)

a) a modification of a product already in the firm's line. ☐

b) a new product similar in type to others in the firm's line. ☐

c) a new product different in type from all others in the firm's line. ☐

7. How different was the selected product from products IN OTHER FIRMS at that time? (check one)

a) the same as a product in another firm's product line ☐
b) an adaptation of a product in another firm's product line ☐
c) an original product similar in type to products in other firm's lines ☐
d) an original product of an entirely new type ☐

8. How important was each of the following factors in the DECISION TO UNDERTAKE THE PRODUCT DEVELOPMENT?

	Not Important	Somewhat Important	Important	Very Important
a) Reaction to foreign competitors	☐	☐	☐	☐
b) Reaction to domestic competitors	☐	☐	☐	☐
c) Exploitation of new technology	☐	☐	☐	☐
d) Market opportunity	☐	☐	☐	☐
e) Customer demand	☐	☐	☐	☐
f) Supplier input	☐	☐	☐	☐
g) Manufacturing efficiency	☐	☐	☐	☐
h) Product quality improvement	☐	☐	☐	☐
i) Government regulations	☐	☐	☐	☐

j) Other (please describe & indicate importance)

____

9. Did the prior introduction of new manufacturing processes in the firm lead to the product change?

NO ☐ YES ☐ If YES, please explain why.

10. Have YOU protected this product with patents?

	YES	NO
Patents	☐	☐

11. Have you protected this product by means other than patents?

NO ☐ YES ☐ If YES, please describe.

12. How important was each of the following as a source of information and expertise in developing the product?

	Not Important	Somewhat Important	Important	Very Important
a) senior management	☐	☐	☐	☐
b) customers	☐	☐	☐	☐
c) R&D department or equivalent	☐	☐	☐	☐
d) shop floor	☐	☐	☐	☐
e) sales force	☐	☐	☐	☐
f) suppliers	☐	☐	☐	☐
g) competitors	☐	☐	☐	☐
h) parent or affiliate	☐	☐	☐	☐
i) university	☐	☐	☐	☐
j) New Brunswick MTC's or RPC or CADMI	☐	☐	☐	☐
k) trade associations/journals	☐	☐	☐	☐
l) independent inventor	☐	☐	☐	☐
m) personal contacts	☐	☐	☐	☐

n) other (please describe & indicate importance)

13. Approximately what was the percentage of total expenditures for the product change spent on each of these phases of the development process?

a) Research ________ %

b) Development (engineering, layout, design, prototypes etc.) ________ %

c) Manufacturing start-up ________ %

d) Marketing start-up ________ %

14. Which statement best describes who was responsible for the product change? (check one)

a) The firm did it all ☐

b) The firm did most of it ☐

c) The firm did some of it and relied on outside sources for support ☐

d) The firm relied mainly on outside sources ☐

e) The firm relied entirely on outside sources ☐

15. Did this product change lead to manufacturing process changes? (check all appropriate)

a) New manufacturing process ☐

b) Significant modification of existing processes ☐

c) Minor adjustments to existing processes ☐

Describe the process change (if any)

16. What percentage of the total sales of the product over the last 2 years has gone to each of the following markets?

a) New Brunswick _____%

b) Atlantic Region outside New Brunswick _____%

c) Canada outside Atlantic Region _____%

d) U.S.A. _____%

e) Other _____%

Please specify ________________

17. What percentage of the total sales of the product goes to each of the following end-user markets?

a) Consumer _____%

b) Industrial _____%

d) Government _____%

e) Institutional (non-government) _____%

18. Did you have difficulties with any of the following in developing or introducing the product?

	No Difficulties	Few Difficulties	Some Difficulties	Many Difficulties	Not Applicable
a) Financing	☐	☐	☐	☐	☐
b) Locating suppliers	☐	☐	☐	☐	☐
c) Technical areas	☐	☐	☐	☐	☐
d) Locating expertise from outside	☐	☐	☐	☐	☐
e) Acquiring skilled personnel	☐	☐	☐	☐	☐
f) Government (regulations, etc.,)	☐	☐	☐	☐	☐
g) Marketing	☐	☐	☐	☐	☐

h) Other (please specify)

____

19. Over the last 5 years, how many significant product changes has your firm introduced?

_________ changes

Section 2 - Product Technologies

This section deals with TECHNOLOGIES associated with the product you have selected. Some questions in this section are similar to questions in Section 1, but they are specifically about the TECHNOLOGIES associated with the product.

1. In which of the following areas did this product change require technology new to the firm?
(check all appropriate)

	New to the Firm
a) materials	☐
b) components	☐
c) product design	☐
d) packaging	☐
e) distribution	☐
f) manufacturing	☐
g) post purchase service	☐
h) other	☐

(specify) ____________________

If the selected change did not require any technologies new to the firm, go to question 4.

2. Did you get any new technologies for the product change from the following sources?

	Yes	No
a) parent	☐	☐
b) affiliate or subsidiary	☐	☐
c) supplier	☐	☐
d) joint venture partner	☐	☐
e) New Brunswick MTC's or RPC or CADMI	☐	☐
f) inventor or consultant	☐	☐
g) competitor	☐	☐
h) other (specify below)		

3. Which statement best describes who was responsible for bringing to your firm the KNOW- HOW associated with the new product technology?

a) We did it all ourselves	☐
b) We did most of it ourselves	☐
c) We did some of it ourselves and relied on outside sources for support	☐
d) We relied mainly on outside sources	☐
e) We relied entirely on outside sources	☐

4. Where are the major suppliers and consultants for the technologies associated with the product. (check all appropriate)

	New Brunswick	Atlantic Region outside N.B.	Other Canada	United States	Other (please specify)
a) Technology suppliers	☐	☐	☐	☐	
b) Technology consultants	☐	☐	☐	☐	

5. Have large distances from the following created difficulties in the development of the product change?

	No Difficulties	Few Difficulties	Some Difficulties	Many Difficulties
a) Technology suppliers	☐	☐	☐	☐
b) Technology consultants	☐	☐	☐	☐

Other (please specify)____

6. Briefly describe anything that in HINDSIGHT would have helped your firm acquire the technology required for this product change.

7. How important has each of the following been as a source of TECHNOLOGICAL information and expertise in developing product changes?

	Not Important	Somewhat Important	Important	Very Important
a) senior management	☐	☐	☐	☐
b) middle production management	☐	☐	☐	☐
c) R&D department or equivalent	☐	☐	☐	☐
d) shop floor	☐	☐	☐	☐
e) plant maintenance	☐	☐	☐	☐
f) suppliers	☐	☐	☐	☐
g) competitors	☐	☐	☐	☐
h) parent or affiliate	☐	☐	☐	☐
i) university	☐	☐	☐	☐
j) New Brunswick MTC's or RPC or CADMI	☐	☐	☐	☐
k) trade associations/journals	☐	☐	☐	☐
l) independent inventor	☐	☐	☐	☐
m) personal contacts	☐	☐	☐	☐

n) other (describe below)

8. How useful would you find each of the following for the transfer of product technology information and expertise to your firm?

	Not Useful	Somewhat Useful	Useful	Very Useful
a) Technical information centres located in New Brunswick.	☐	☐	☐	☐
b) Consulting services which communicate by phone, fax, and report.	☐	☐	☐	☐
c) Consulting services which travel to your firm.	☐	☐	☐	☐
d) User operated computer links from your firm to information networks.	☐	☐	☐	☐
e) Computer links to information networks available at information centres.	☐	☐	☐	☐

9. Briefly describe anything, including services from public sector agencies, that would help your firm acquire product technologies in the FUTURE.

10. Do you have any comments on this questionnaire or the study?

Thank you for your participation

Manufacturing Process Questionnaire

Firm:

Name of Respondent:

Position of Respondent:

This questionnaire deals with manufacturing processes and the technologies associated with them. The focus is on change. The questionnaire asks about an individual manufacturing process in your firm. There are 3 sections:

Section 1 - Process Development
Section 2 - Process Technologies
Section 3 - Workforce

You are asked to select one manufacturing process change that has been introduced to the firm's operations within the last ten years. This change could be a totally new process or a modification of existing processes. Throughout this questionnaire whenever you are asked to comment on the process change it refers to the process you choose now.

Should you have any questions about this survey please contact :

Peggy Wight, Research Associate
Technology Diffusion Project
Mount Allison University
Sackville, N.B, E0A 3C0.
telephone: (506) 364-2624 fax: (506) 364-2625

DATE:

PHONE BACK DATE:

Section 1 - Process Change

This section deals with how the process change was developed and implemented in your firm.

1. Name the manufacturing process associated with the process change.

2. Briefly describe this manufacturing process.

3. What was new or different about this process change?

4. In what year did your firm first commit significant resources toward developing the process change?

19___

5. In what year did your firm first use the changed process in its regular operations?

19___

6. How different was the changed process from other processes IN YOUR FIRM at the time of development? (check one)

- a) a modification of a process already in use in your firm ☐
- b) a new process similar in type to processes already in use in your firm ☐
- c) a new process different in type from processes already in use in your firm ☐

7. When it was developed, how different was the changed process from processes IN OTHER FIRMS? (check one)

a) the same as processes already in use in other firms ☐

b) similar to processes already in use in other firms ☐

c) different from processes already in use in other firms ☐

8. How important was each of the following factors in the DECISION TO UNDERTAKE THE PROCESS CHANGE?

	Not Important	Somewhat Important	Important	Very Important
a) Reaction to foreign competitors	☐	☐	☐	☐
b) Reaction to domestic competitors	☐	☐	☐	☐
c) Exploitation of new technology	☐	☐	☐	☐
d) Labour reduction	☐	☐	☐	☐
e) Energy reduction	☐	☐	☐	☐
f) Capital requirement reduction	☐	☐	☐	☐
g) Supplier input	☐	☐	☐	☐
h) Product quality improvement	☐	☐	☐	☐
i) Government regulations	☐	☐	☐	☐

j) Other (please describe and indicate importance)

____

9. Have you shared information about the process change with other firms on an informal basis?

YES ☐ NO ☐

10. Have YOU protected this process change with patents?

YES ☐ NO ☐

11. Have YOU protected the process change by means other than patents?

NO ☐ YES ☐ If YES, please describe:

12. How important was each of the following as a source of information and expertise in developing the process change?

	Not Important	Somewhat Important	Important	Very Important
a) senior management	☐	☐	☐	☐
b) middle production management	☐	☐	☐	☐
c) R&D department or equivalent	☐	☐	☐	☐
d) shop floor	☐	☐	☐	☐
e) plant maintenance	☐	☐	☐	☐
f) suppliers	☐	☐	☐	☐
g) competitors	☐	☐	☐	☐
h) parent or affiliate	☐	☐	☐	☐
i) university	☐	☐	☐	☐
j) New Brunswick MTC's or RPC or CADMI	☐	☐	☐	☐
k) trade associations/journals	☐	☐	☐	☐
l) independent inventor	☐	☐	☐	☐
m) personal contacts	☐	☐	☐	☐

n) other (describe below)

____

13. Approximately what was the percentage of total expenditures for the process change spent on each of these phases of the development process?

a) Research ______ %

b) Development (engineering, layouts, design, prototypes, etc.) ______ %

c) Implementation (start-up, training, etc.) ______ %

14. Which statement best describes who was responsible for the process change? (check one)

a) The firm did it all	☐
b) The firm did most of it	☐
c) The firm did some of it and relied on outside sources for support	☐
d) The firm relied mainly on outside sources	☐
e) The firm relied entirely on outside sources	☐

15. Did you have difficulties with any of the following in developing or implementing the process change?

	No Difficulties	Few Difficulties	Some Difficulties	Many Difficulties	Not Applicable
a) Financing	☐	☐	☐	☐	☐
b) Locating suppliers	☐	☐	☐	☐	☐
c) Technical areas	☐	☐	☐	☐	☐
d) Locating expertise from outside	☐	☐	☐	☐	☐
e)Acquiring skilled personnel	☐	☐	☐	☐	☐
f) Government (regulations, etc.,)	☐	☐	☐	☐	☐
g) Other (please specify)					

____

16. Did the process change lead to product change in your firm?

	YES	NO
a) New product development	☐	☐
b) Modification of existing products	☐	☐

Describe the product change (if any): ____

17. How many significant manufacturing process changes has your firm implemented over the last 5 years?

______ changes

18. Have you commercialized and marketed any aspect of this CHANGED PROCESS?

YES ☐ NO ☐

If the changed process was not commercialized and marketed, go to section 2.

19. What aspect of the process have you commercialized?

Section 2 - Process Technologies

This section deals with TECHNOLOGIES associated with the manufacturing process change you chose. Some questions in this section are similar to questions in Section 1, but they are specifically about the TECHNOLOGIES associated with the process change.

1. In which of the following areas did the process change require technology new to the firm? (check all appropriate)

	New to the Firm
a) basic process technology	☐
b) materials technology	☐
c) materials handling technology	☐
d) machine tool technology	☐
e) machine control technology	☐
f) testing & monitoring technology	☐
g) information system technology	☐
h) packaging technology	☐
i) maintenance technology	☐
j) physical plant technology	☐
k) other (describe below)	☐

If the process change did not involve any technologies new to the firm, go to question 4 of this section.

2. For the process change, did you get any technologies from the following sources?

	Yes	No
a) parent	☐	☐
b) affiliate or subsidiary	☐	☐
c) supplier	☐	☐
d) joint venture partner	☐	☐
e) New Brunswick MTC's or RPC or CADMI	☐	☐
f) inventor or consultant	☐	☐
g) competitor	☐	☐

h) other (specify below)

____

3. Which statement best describes who was responsible for bringing to your firm the KNOW-HOW associated with the new technology ? (check one)

a) The firm did it all	☐
b) The firm did most of it	☐
c) The firm did some of it and relied on outside sources for support	☐
d) The firm relied mainly on outside sources	☐
e) The firm relied entirely on outside sources	☐

4. Where are the major suppliers and consultants for the technologies involved in the changed process? (check all appropriate)

	New Brunswick	Atlantic Canada outside N.B.	Other Canada	United States	Other (please specify)
a) Technology suppliers	☐	☐	☐	☐	
b) Technology consultants	☐	☐	☐	☐	

5. Did large distances from either of the following create difficulties in the development of the process change?

	No Difficulties	Few Difficulties	Some Difficulties	Many Difficulties
a) Technology suppliers	☐	☐	☐	☐
b) Technology consultants	☐	☐	☐	☐

Other (please specify)____

6. Briefly describe anything that in HINDSIGHT would have helped your firm acquire the technology required for this process change.

7. How important has each of the following been as a source of TECHNOLOGICAL information and expertise in developing process changes in your firm?

	Not Important	Somewhat Important	Important	Very Important
a) senior management	☐	☐	☐	☐
b) middle production management	☐	☐	☐	☐
c) R&D department or equivalent	☐	☐	☐	☐
d) shop floor	☐	☐	☐	☐
e) plant maintenance	☐	☐	☐	☐
f) suppliers	☐	☐	☐	☐
g) competitors	☐	☐	☐	☐
h) parent or affiliate	☐	☐	☐	☐
i) university	☐	☐	☐	☐
j) New Brunswick MTC's or RPC or CADMI	☐	☐	☐	☐
k) trade associations/journals	☐	☐	☐	☐
l) independent inventor	☐	☐	☐	☐
m) personal contacts	☐	☐	☐	☐

n) other (describe below)

____

8. How useful would you find each of the following for the transfer of process technology information and expertise to your firm?

	Not Useful	Somewhat Useful	Useful	Very Useful
a) Technical information centres located in New Brunswick.	☐	☐	☐	☐
b) Consulting services which communicate by phone, fax, and report.	☐	☐	☐	☐
c) Consulting services which travel to your firm.	☐	☐	☐	☐
d) User operated computer links from your firm to information networks.	☐	☐	☐	☐
e) Computer links to information networks available at information centres.	☐	☐	☐	☐

9. Briefly describe anything, including services from public sector agencies, that would help the firm acquire process technologies in the FUTURE.

Section 3 - Workforce

This section deals with the workforce associated with the selected process change. In the following questions the term LINE WORKERS refers to those who operate the production line.

1. How many LINE WORKERS are there in the section associated with this process change?

_____ line workers

2. Was there a change in the number of LINE WORKERS as a result of the process change?

YES ☐ NO ☐ If NO, go to QUESTION 4

3. What was the approximate percentage change in the number of LINE WORKERS as a result of the process change?

_____ % INCREASE

_____ % DECREASE

4. Was there a change in the number of SUPPORT WORKERS (engineers, technicians, maintenance, etc.,) as a result of the process change?

YES ☐ NO ☐ If NO, go to QUESTION 6

5. What was the approximate percentage change in the number of SUPPORT WORKERS as a result of the process change?

_____ % INCREASE

_____ % DECREASE

6. In the section affected by the process change has the role of SUPPORT WORKERS increased or decreased in importance as a result of the process change? (check one)

a) INCREASED IMPORTANCE ☐

b) NO CHANGE ☐

c) DECREASED IMPORTANCE ☐

7. In the case of LINE WORKERS affected by the process change, what was the level of education required after the change? (check all appropriate)

Grade School	Some High School	High School	Some College or Trade School	College or Trade School	Some University	University
☐	☐	☐	☐	☐	☐	☐

8. Did the process change lead to a change in the level of education required of LINE WORKERS affected by the process change? (check one)

a) INCREASE ☐

b) NO CHANGE ☐

c) DECREASE ☐

9. Have you laid off any LINE WORKERS as a result of the process change?

NO ☐

YES ☐

If YES, then WHY?

____

____

____

10. In the case of LINE WORKERS, how important was each of the following to the SUCCESSFUL adoption of the process change?

	Not Important	Somewhat Important	Important	Very Important
a) Willingness to change	☐	☐	☐	☐
b) Job security	☐	☐	☐	☐
c) Skills	☐	☐	☐	☐
d) Pay incentives	☐	☐	☐	☐
e) More interesting work	☐	☐	☐	☐

f) Other (please specify)

____

11. In the case of LINE WORKERS, how important was each of the following in INHIBITING the adoption of the process change?

	Not Important	Somewhat Important	Important	Very Important
a) Unwillingness to change	☐	☐	☐	☐
b) Jobs threatened	☐	☐	☐	☐
c) Insufficient skills	☐	☐	☐	☐
d) No pay incentives	☐	☐	☐	☐
e) Less interesting work	☐	☐	☐	☐

f) Other (please specify)

____

12. Briefly describe anything that in HINDSIGHT would have helped the successful adoption of the process change by LINE WORKERS.

13. In the case of LINE WORKERS how important is each of the following skills to the changed process?

	Not Important	Somewhat Important	Important	Very Important
a) physical strength	☐	☐	☐	☐
b) manual dexterity	☐	☐	☐	☐
c) technical ability	☐	☐	☐	☐
d) literacy	☐	☐	☐	☐
e) computer skills	☐	☐	☐	☐

f) other (please specify) ____________________

14. In the case of LINE WORKERS how has each of the following skill requirements changed as a result of the process change?

	Major Decrease	Some Decrease	No Change	Some Increase	Major Increase
a) physical strength	☐	☐	☐	☐	☐
b) manual dexterity	☐	☐	☐	☐	☐
c) technical ability	☐	☐	☐	☐	☐
d) literacy	☐	☐	☐	☐	☐
e) computer skills	☐	☐	☐	☐	☐

f) other (please specify) ____________________

If no skill requirements have increased, go to question 17.

15. How have you met increased skill demands for LINE WORKERS resulting from the process change?
(check all appropriate.)

a) Hired skilled workers ☐

b) Trained new workers ☐

c) Retrained existing workers ☐

d) Other (please specify)

16. How have you trained LINE WORKERS for the changed process ?
(check all appropriate)

a) On the job ☐

b) Formal training inhouse ☐

c) Formal training outside ☐

d) Other (please specify)

17. Do you have any comments on this questionnaire or the study?

Thank you for your participation

APPENDIX 3

How to Read the Composite Tables

These tables in this report were produced with the Tables procedure of SPSS/PC+. Many of the tables used in this report are composite crosstabulations which concentrate a lot of information which could be contained in a series of tables in one table. This technique affects the totals and calculations in the table. As a guide to this type of table we will outline the various parts of these tables. We will use table one, which is reproduced below as our example.

All of these tables have columns, most commonly for small, medium, and large firms. There are three sets of rows for each factor. The first row is the number of cases which fall into the crosstabulation. In the example below we have 10 small firms who claim that process technology changed in the process innovation. The row percentage is the next number down. That is 38.5% of firms which stated that process technologies changed were small in size. If we follow along this row to the last column labelled Total we have a row total of 26 firms which stated that process technologies changed. These row numbers add up. Column numbers however do not add up. If you added up all of the totals in the total column going down the column you would get 26+10+12+15+17+10+6+7+12+4=119. The bottom right corner of the table has the total number of cases for this set of questions as 39. This is the number of firms which made valid responses for this set of questions. However, each factor is a separate question. In terms of the issues in this table, each firm may indicate a variety of new technologies. These tables ensure that the number of firms is not inflated since the 119 number mentioned above would be the number of technologies indicated by these firms and not the number of firms. The columns do not add up because this is a composite of responses. So in the first factor again in the top right hand corner, the 26 firms of all sizes adds up to 100% for the row but is 66.7% of the 39 firms who answered this set of questions. Similarly, going down the marginal total column on the right, 10 firms indicated materials technologies and this is 25.6% of the 39 relevant firms. The same type of logic prevales for column calculations in the individual columns. Using the example again of small firms with new process technologies, 10 or 76.9% of all relevant small firms, the 13 at the base of the column, indicated this as a factor. The base figure in each column is the total for each type of firm. Row percents in this case are not relevant, they always add up to 100. The column percents give the total percentage of firms of this type. In this case 33.3% of all firms which validly answered these questions were small.

Table 1 New Technologies in Process Innovations

	FIRM SIZE			Total
	Small	Medium	Large	
New Technologies				
Process.............	10	7	9	26
....	38.5%	26.9%	34.6%	100.0%
....	76.9%	58.3%	64.3%	66.7%
Materials...........	4	3	3	10
....	40.0%	30.0%	30.0%	100.0%
....	30.8%	25.0%	21.4%	25.6%
Materials Handling..	3	3	6	12
....	25.0%	25.0%	50.0%	100.0%
....	23.1%	25.0%	42.9%	30.8%
Machine tool........	6	3	6	15
....	40.0%	20.0%	40.0%	100.0%
....	46.2%	25.0%	42.9%	38.5%
Machine control.....	6	3	8	17
....	35.3%	17.6%	47.1%	100.0%
....	46.2%	25.0%	57.1%	43.6%
Testing monitoring..	4	4	2	10
....	40.0%	40.0%	20.0%	100.0%
....	30.8%	33.3%	14.3%	25.6%
Info systems........	1	2	3	6
....	16.7%	33.3%	50.0%	100.0%
....	7.7%	16.7%	21.4%	15.4%
Packaging...........	0	3	4	7
....	.0%	42.9%	57.1%	100.0%
....	.0%	25.0%	28.6%	17.9%
Maintenance.........	4	4	4	12
....	33.3%	33.3%	33.3%	100.0%
....	30.8%	33.3%	28.6%	30.8%
Physical plant......	0	1	3	4
....	.0%	25.0%	75.0%	100.0%
....	.0%	8.3%	21.4%	10.3%
Total...............	13	12	14	39
....	100.0%	100.0%	100.0%	100.0%
....	33.3%	30.8%	35.9%	100.0%